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Vol. CXXXIV.—No. 3493] LONDON: FRIDAY EVENING, DECEMBER 8, 1922 [Price One Shilling By Inland Post 1s. 3d.

PUBLIC NOTICES

The Institute of Physics.

APPOINTMENTS REGISTER AND REGISTER OF CONSULTING PHYSICISTS.

The Appointments Register Committee is prepared to recommend to Public Departments, Universities and Colleges, Directors of Research, Manufacturers, and others desirous of employing or consulting fully qualified Physicists, suitable persons possessing special knowledge of any branch of physics.

By Order of the Board,
F. S. SPIERS,
Secretary.

10, Essex-street,
London, W.C. 2. 488

Administrative County of LONDON.

SOUTH-WESTERN STORM RELIEF SEWER, CONTRACT No. 3.

TENDERS are INVITED for the CONSTRUCTION in tunnel of an 11ft. 4in. internal diameter SEWER in iron, of a total length of about 1 3-8 miles, together with outlet to the river Thames, Weir Chambers, Tumbling Bays, Side Entrances, &c., in the Metropolitan Boroughs of Lambeth, Wandsworth and Battersea.

The specification, form of Tender, &c., may be obtained on application to the Chief Engineer of the Council at Old County Hall, Spring-gardens, S.W. 1, upon payment of the sum of £10. This amount will be returnable only if the tenderer shall have sent in a bona fide Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the contract documents may be inspected before the payment of the fee.

No Tender received at the County Hall, Spring-gardens, S.W. 1, after Twelve Noon on Tuesday, 9th January, 1923, will be considered. The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
Clerk of the London County Council.

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Bombay, Baroda, and Central INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Wednesday, 20th December, TENDERS for the SUPPLY of—

FENCING MATERIALS.

Tenders must be made on forms, copies of which, with specification, can be obtained at these offices on payment of 10s. each (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.

Offices, 91, Petty France,
Westminster, S.W. 1,
5.12.22. 913

East Indian Railway.

The Directors are prepared to receive up to Eleven o'clock a.m. TENDERS for the SUPPLY of :—

(1) HELICAL and VOLUTE SPRINGS.
(2) INDIA-RUBBER FITTINGS.
(3) STEEL MATERIAL (Channels and Plates).
(4) WHEELS and AXLES.
(5) DUPLICATE PARTS and FITTINGS for CARRIAGES and WAGONS.

for Nos. 1, 2, 3, and 4 on Wednesday, the 20th December instant, and for No. 5 on Wednesday, the 3rd January proximo.

Copies of the specifications can be obtained at the Company's offices on payment of £1 1s. each. This fee will not be returned.

G. E. LILLIE,
Secretary.

73-76, King William-street, London, E.C. 4,
7th December, 1922. 956

Southborough Urban District COUNCIL.

WATER MAIN.

The Southborough Urban District Council invite TENDERS for the PROVISION and LAYING of about 1500 Yards of 16in. CAST IRON WATER MAIN and 6in., 4in., and 3in. Connections to Existing Branches in the Main Road, Southborough, in accordance with the plans and specification prepared by the Engineers, Messrs. G. and F. W. Hodson, of Bank Chambers, Loughborough, and London.

Plans and specifications can be inspected at the Council Offices, Southborough, and schedules of quantities may be obtained from the Engineers on deposit of the sum of £5 5s., which will be returned after the receipt of a bona fide Tender.

Tenders, on the form provided, in sealed envelopes, addressed to the undersigned, must be delivered at the Council Offices, Southborough, on or before Thursday, 28th day of December, 1922.

The Council do not bind themselves to accept the lowest or any Tender.

PHILIP HANMER,
Clerk to Council.

Council Offices,
Southborough.
2nd December, 1922. 907

The Great Indian Peninsula RAILWAY COMPANY.

The Directors are prepared to receive TENDERS for the SUPPLY of the following STORES, namely :—

No.		Fee for specification.
1.	STEEL FISH BOLTS, SPIKES, &c.	10s.
2.	POINTS and CROSSINGS	10s.
3.	GALVANISED WROUGHT IRON WATER TUBES, &c.	10s.
4.	MILD STEEL BARS, SECTIONS, &c., for MISCELLANEOUS PURPOSES	£1
5.	STEEL DRAW-BARS for WAGONS	10s.
6.	TYRE RETAINING RINGS	7s. 6d.
7.	STEEL TYRES for CARRIAGES and WAGONS	10s.
8.	SPARE PARTS for LOCOMOTIVE ENGINES	£1
9.	GALVANISED CORRUGATED SHEETS, &c.	7s. 6d.
10.	BRASS and IRON or STEEL SCREWS	10s.
11.	GALVANISED STAMPED STEEL MORTAR PANS	2s. 6d.

Specifications and forms of Tender may be obtained at this office on payment of the fee for the specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and postal orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Steel Fish Bolts, Spikes, &c.," or as the case may be, not later than Eleven o'clock a.m. on Tuesday, the 19th December, 1922.

The Directors do not bind themselves to accept the lowest or any Tender,

B. H. WALPOLE,
Secretary.

Company's Offices,
48, Copthall-avenue, E.C. 2,
London, 6th December, 1922. 943

The Engineer

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PUBLIC NOTICES

Napier Harbour Board, New ZEALAND.

TENDERS are INVITED for the SUPPLY and DELIVERY c.i.f. & E. Napier Wharf of a STEAM HAMMER for PILE DRIVING.

Specifications may be obtained from the Board's agents—

Messrs. W. and A. McARTHUR, Ltd.,
18/19, Silk-street,
Cripplegate, London, E.C. 2.

Tenders to reach New Zealand by 8th January, 1923. 928

Romford Rural District Council. SOUTH HORNCHURCH SEWER. No. 2 SECTION.

The Council invite TENDERS for the CONSTRUCTION of about 1060 Yards of 12in. diameter STONEWARE PIPE SEWER, with Branches, Manholes, Ventilators and other work incidental thereto, in Southend-road, Hornchurch, Essex.

Drawings, specification and quantities can be seen at the office of Mr. W. J. Grant, Surveyor to the Council, 16a, South-street, Romford; also at the office of Mr. William Fairley, Consulting Engineer, Parliament Mansions, Victoria-street, Westminster, S.W.

Tenders must be delivered to the undersigned on or before Monday, December 18th, 1922.

The Council do not bind themselves to accept the lowest or any Tender.

T. W. A. GREENHALGH,
Clerk to the Council.

16a, South-street, Romford,
December 2nd, 1922. 899

Stevenage Urban District COUNCIL.

SALE OF WATERWORKS PUMPS.

The above-named Council invite TENDERS for the PURCHASE of a SET of THREE-THROW DEEP WELL SINGLE-ACTING LIFT and FORCE PUMPS, together with 6in. CAST IRON RISING MAIN to surface, and TOP GEARING, by Messrs. Glenfield and Kennedy, Ltd., Kilmarnock, in good condition, fixed in a well 175ft. deep, at the Stevenage Waterworks, the purchaser to remove the same at his own expense.

Tenders, marked "Tender for Pumps," to be received by me not later than Saturday, the 16th December, 1922.

W. O. TIMES,
Clerk to the Council.

Council Offices, Stevenage. 862

Madras Port Trust.

APPOINTMENT OF DEPUTY CHIEF ENGINEER TO THE PORT OF MADRAS.

APPLICATIONS in writing for the above APPOINTMENT will be RECEIVED by the undersigned on behalf of the Trustees of the Port of Madras up to the 31st December, 1922. Candidates must have previous practical experience on Dock and Harbour Works, and preferably a knowledge of Reinforced Concrete Design and Constructions.

SALARY.—Rs. 1375 per mensem, rising by annual increments of Rs. 50 to Rs. 1675 per mensem, with a house-rent allowance of Rs. 60 per mensem.

The selected candidate will be required to join as soon after the end of January, 1923, as possible. Applicants should forward copies of testimonials, which will not be returned, and also particulars of nationality, education, age, diplomas or degrees, accompanied by a record in chronological order of candidates' training and subsequent experience.

The selected candidate will be required to enter into an agreement for a period of three or five years, and will be provided with free first-class passage for himself to Madras and return passage to England on termination of his agreement, subject to the conditions of his agreement.

RENDEL, PALMER and TRITTON,
12/14, Dartmouth-street,
Westminster, S.W. 1. 920

SITUATIONS OPEN

WANTED, a Capable ELECTRICAL ENGINEER. Preference given to man experienced in Colliery and Iron and Steel Works Equipment.—Address, giving full particulars of experience and training, age, and salary required, 909, The Engineer Office. 909 A

WANTED, ENGINEER, to Take Charge of Smokeless Fuel and Briquetting Plant. House with garden available. Applicant willing to invest £500 preferred if fully qualified.—Address, 904, The Engineer Office. 903 A

TUBE AND PIPE TRADE.

WANTED by an Engineering Firm in London, a DEPARTMENT MANAGER, to deal with Sales of Tube and Pipe Fittings, to build up new business at home and abroad, and to establish new agencies.

Essentials: a thorough knowledge of the pipe and tube trade; ability to influence business from British users; ability to select and control indoor and outdoor staff; familiarity with every detail of business procedure; negotiation of contracts, appointment of foreign representatives, &c. Those unable to bring forward evidence of undoubted success in a similar work are requested not to apply.

Applications will be considered in the strictest confidence and should be made in the first instance to 910, The Engineer Office. 910 A

WANTED, for an Established Steel Works in the North of England, a COMMERCIAL MANAGER, to TAKE CHARGE of SALES and the GENERAL BUSINESS of the FOUNDRY.

Experience with Electric Furnaces and Large Power Station management an advantage.

Output 25 tons per week, capable of large development. Good prospects for the right man.

Address, with photo and full particulars of experience, references, age and salary required, 955, The Engineer Office. 955 A

TO DEVELOP TRADE IN FITTINGS FOR CAST IRON PIPES.

WANTED, in London, First-class MAN, to Develop Sale of Fittings for Cast Iron Pipes. Applications wanted only from men who are thoroughly familiar with the cast iron pipe trade from the users' and manufacturers' point of view. Preference will be given to anyone having a connection amongst British pipe users and knowledge of overseas markets. The position offers great scope for development to an energetic capable man who has proved his ability to build up business.—Address, giving full details, salary required, 911, The Engineer Office. 911 A

CONSTRUCTIONAL STEEL WORK.—GENERAL MANAGER WANTED, to act as Assistant to Managing Director; technical, practical and commercial experience essential; must be fully qualified. Preference given to one having held similar position. State experience fully and salary required, in strictest confidence (Lancashire district).—Address, P6548, The Engineer Office. P6548 A

ENGINEER-ELECTRICIAN REQUIRED to Undertake study Overseer. Capable of organising maintenance of large Printing Plant, &c., together with the Electrical Equipment.—Progressive young man should address, 948, The Engineer Office. 948 A

LOCO. AND WAGON SHOP SUPERINTENDENT.—WANTED, for Railway in Central America, a MAN experienced in Erection and Maintenance of Locomotives, Carriages and Wagons. Knowledge of Spanish essential.—Write full particulars of past experience and salary expected, to "C. D.," c/o Street's, 30, Cornhill, E.C. 3. 905 A

REPRESENTATIVE WANTED AT ONCE for Japan by large High-grade Steel Firm. Only those with energy and push and with thorough knowledge of Tool Steels and Japanese local conditions need apply.—Address, stating experience and enclosing copies of references, P6562, The Engineer Office. P6562 A

SITUATIONS OPEN (continued)

SMART COMMERCIAL ENGINEER WANTED, about 30, to Sell Heavy Pulverisers. Essentials are: good selling record and correspondent and experience with Cement and Fertiliser Works and Collieries. Languages advantageous.—Address, stating salary, when free, &c., 942, The Engineer Office. 942 A

WELL-KNOWN FIRM of Building Contractors and Engineers REQUIRE competent MANAGER to Take Entire Charge of the Building Department. Practical experience essential. State experience fully and salary required, in strictest confidence (Lancashire district).—Address, P6564, The Engineer Office. P6564 A

WANTED, a DRAUGHTSMAN, Experienced in Hydraulic Machinery and Cranes. State age, experience, references, and salary required.—Address, 940, The Engineer Office. 940 A

WANTED, DRAUGHTSMAN, About 30 Miles from London, preferably accustomed to I.C. Engines. Must be accurate and reliable.—Address, 929, The Engineer Office. 929 A

WANTED, for London, YOUNG ENGINEER DRAUGHTSMAN, with good technical and up-to-date knowledge of Crushing, Screening and Cement Machinery. State age, experience, when free, and salary required.—Write, Box 616, Advertising Offices, 84, Queen Victoria-street, London, E.C. 4. 936 A

WANTED, SEVERAL FIRST-CLASS DRAUGHTSMEN as Leading Hands on Switchgear Work. Age, salary, experience and when disengaged.—Address, 893, The Engineer Office. 835 A

WANTED, Good SENIOR DRAUGHTSMAN with Lay-out Experience on Electrical Side of Central Stations. Age, salary, and when disengaged.—Address, 854, The Engineer Office. 854 A

A JUNIOR ENGINEERING ASSISTANT is REQUIRED in the Drawing-office of an important Municipal Undertaking in the Midlands.

The successful applicant must be a good draughtsman and have had a suitable training in Waterworks Engineering and Surveying. Preference will be given to Associate Members or Students of the Institution of Civil Engineers.

Applications stating age, experience, qualifications, and salary required, together with copies of three recent testimonials, to be sent to 858, The Engineer Office. 858 A

A VACANCY OCCURS in the Drawing-office of a London firm of Reinforced Concrete Specialists for a JUNIOR ENGINEER and DRAUGHTSMAN: experience is not essential, but applicants, to whom the appointment offers good prospects, must have a sound knowledge of Mathematics and hold a good Engineering Degree.—Address, with full particulars of education and training, and copies of testimonials, 951, The Engineer Office. 951 A

AN Old-established FIRM of CONSTRUCTIONAL ENGINEERS REQUIRE the SERVICES of an experienced MAN, capable of assuming the full responsibility of a large Drawing-office. The suitable candidate possessing the necessary qualifications and personality an attractive remuneration will be offered.—Address, 939, The Engineer Office. 939 A

DESIGNER, Commercial Vehicle Chassis Construction. Must be fully versed in current practice and design, works training essential; Birmingham district. State in confidence age, full experience, and salary required, also when disengaged, in the first instance.—Address, P6546, The Engineer Office. P6546 A

DRAUGHTSMAN (Leading). Having Good Experience Band Conveyors and Light Steel Structures. Must be competent make all calculations, give quick, accurate, reliable work and co-operate enthusiastically. Full particulars (letter only), training, experience, posts held, salary required.—STEEL BELT CONVEYORS, Ltd., 30, Paradise-street, Birmingham. 913 A

DRAUGHTSMAN.—REQUIRED AT ONCE, in Large Bridge Works, experienced DRAUGHTSMAN capable of Designing and Rapid Detailing of Heavy Bridge Work. Good prospects for suitable man.—Address, "BRIDGE," Wm. Porteous and Co., Advertising Agents, Glasgow. P6558 A

DRAUGHTSMAN WANTED AT ONCE for London office, having good structural and mechanical experience. Only first-class men need apply.—Address, giving outline of training, age, and salary required, 954, The Engineer Office. 954 A

DRAUGHTSMAN.—WANTED, for Manchester District, SENIOR LOCOMOTIVE DRAUGHTSMAN, capable of working out structural and running gear of electric locomotives. Knowledge of electricity not essential. Applications to include age, experience, and salary required.—Address, 860, The Engineer Office. 860 A

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SITUATIONS OPEN (continued)

DRAUGHTSMAN WANTED, Thoroughly Conversant with the Design of all Classes of Centrifugal Pumps, High and Low Lift. Good opening; progressive if experience suitable.—Address, stating age, experience, and salary required, 918, The Engineer Office. 918 A

DRAUGHTSMAN REQUIRED by Firm of Engineers. Must be thoroughly experienced in working out plans for industrial plants, power stations, and general engineering.—Please address, stating age, experience, full technical particulars, and salary, 896, The Engineer Office. 896 A

GOOD DRAUGHTSMAN, Specialised in Switchboard Work, REQUIRED. Must have had good mechanical training. State age, experience, and salary.—Address, 900, The Engineer Office. 900 A

INDIA.—REQUIRED by an English Firm of Bridge and Structural Engineers, a DRAUGHTSMAN, capable of Making Calculations, Taking Out Stresses and Preparing Designs, Estimates and Working Drawings for Bridge and Structural Steel Work. Must be a bachelor, age 25 to 28; if an A.M.I.C.E. it will be a recommendation.—Apply, stating age and full particulars of previous experience, to Z X 383, Deacon's 7, Leadenhall-street, E.C. 3. 940 A

LANCASHIRE FIRM REQUIRES TWO GOOD DRAUGHTSMEN, accustomed to High-class Heavy Engineering Work. State age, experience, and salary.—Address, 945, The Engineer Office. 945 A

STRUCTURAL STEELWORK DRAUGHTSMAN REQUIRED IMMEDIATELY; accustomed to Detailing and Designing Steel-frame Buildings under L.C.C. 1909 Act and General Structural Work.—Address, stating age, experience and salary required, 923, The Engineer Office. 923 A

TOOL DRAUGHTSMAN REQUIRED IMMEDIATELY in the Midlands; must be thoroughly experienced in the Design of Large and Small Special Tools for Cold Press Work. Works experience essential. Progressive post for really capable and energetic man.—Address, stating age, experience, and salary required, 915, The Engineer Office. 915 A

WANTED, All-round MACHINE SHOP FOREMAN, light manufacturing work. State education, apprenticeship, and training, particulars of positions held, and where.—Address, 927, The Engineer Office. 927 A

WANTED, Experienced FOREMAN, to Take Charge of Ornamental Wrought Iron Gate and Railing Shop. Must be able to estimate from drawings and produce first-class work.—Address, stating age, experience, and salary, 907, The Engineer Office. 907 A

WANTED, FOUNDRY FOREMAN, Experienced in Moulding Large Marine Castings and General Heavy Machine Tool Castings.—Apply, THE SHEFFBRIDGE COAL and IRON CO., Ltd., Chesterfield. 764 A

FOREMAN (Machine and Erecting Shop), Accustomed to Colliery Engineering, Haulages, Winding Engines, Repetition Work, and Rate Fixing. None but competent man giving fullest particulars, age and wages need apply.—Address, 936, The Engineer Office. 936 A

WANTED, TOOL SETTERS for Four-spindle Gridley Automatics.—Write, stating experience and salary required, to Box 2256, Willing's, 30, King-street, Covent Garden, W.C. 2. 934 A

WANTED, ESTIMATING CLERK for Railway Rolling Stock. Experienced man only.—Apply, LEEDS FORGE CO., Ltd., Leeds. 914 A

A THOROUGHLY PRACTICAL ESTIMATOR REQUIRED for an up-to-date Machine Shop undertaking the manufacture of High-class Motor and similar Parts on contract basis.

Candidates should have had first-class machine shop and general engineering experience, and be capable of planning operations on most economical lines. Sound experience in tooling up jobs essential, together with ability to fix piecework prices. Previous experience in estimating absolutely necessary.

Address, P6559, The Engineer Office. P6559 A

SITUATIONS WANTED

A. M.I.C.E., M.I.E.E., M.I. Mech. E., over 20 Years' experience and having excellent offices in leading Yorkshire city, also motor car, REQUIRES APPOINTMENT where his services and facilities can be utilised. Principals only.—Write, in first instance, giving particulars and terms suggested, to P6540, The Engineer Office. P6540 B

BUYER.—The MANAGER of a Large Engineering Works Purchasing Dept., who has an exceptionally wide knowledge of the markets of the country, DESIRES to NEGOTIATE NEW APPOINTMENT.—Write, Z. M. 619, c/o Deacon's, Leadenhall-street, E.C. 886 B

CIVIL ENGINEER, Member Inst., good Linguist, wide experience railways, docks, irrigation and public works in general, SEEKS APPOINTMENT at home or abroad; good organiser and administrator. Salary not so much an object as active work.—Address, P6552, The Engineer Office. P6552 B

ENGINEER (36), Demobilised Capt., R.E., late Assist. Director Works, Egypt, wide experience hydes., concrete, survey, drawing-office, &c., excellent organiser, Arabic, Spanish, URGENTLY REQUIRES POSITION with scope; first-class testimonials. Go anywhere.—Address, P6553, The Engineer Office. P6553 B

ENGINEER, Structural and General (35), 17 Years' experience, shops, D.O., commercial, and past 3 years WORKS MANAGER to large European firm in India, is DESIROUS of CHANGE; energetic, excellent organiser, thoroughly experienced design, estimating and general engineering sales; open to offer AT HOME OR ABROAD.—Address, P6541, The Engineer Office. P6541 B

ENGINEER, Electrical, Mechanical, Civil and petroleum, 2 years Finsbury College, 5 years British Westinghouse, 7 years large cotton mill association, Manchester, 7 years important administration appointment large oil company, Persia, 1 year large contract work for same oil company, which now successfully completed, SEEKS SENIOR APPOINTMENT at home or abroad, preferably former; at present in England.

Address, P6540, The Engineer Office. P6540 B

ENGINEER, Young, Active, Capable, with Excellent commercial and technical training, first-rate education and address, proved salesman and organiser, SEEKS RESPONSIBLE POSITION on inside or outside staff; highest references.—Address, P6547, The Engineer Office. P6547 B

GENTLEMAN DESIRES SIT. as DRAUGHTSMAN. Experience; 10 years rolling vehicle, 6 years mech. detail and general engineering; age 30.—Address, P6537, The Engineer Office. P6537 B

MANAGER of General Engineering Works, including boiler shop and foundries, with experience on repetition work, accustomed to control of office, staff and shops, DESIRES SIMILAR ENGAGEMENT at an early date; age 42.—Address, P6520, The Engineer Office. P6520 B

SALES ENGINEER. Age 29, Married, Aff. M.I.E. (Ind.), DESIRES POSITION at home or abroad; experience all engines, hydraulics, compressed air plant, internal combustion engines, drawing-office and shipyard experience; good technical and practical training; good references; 3 years manager, India, well-known firm.—Address, P6544, The Engineer Office. P6544 B

SALES ENGINEER SHORTLY DISENGAGED. Practical, theoretical and commercial experience in marine, mining, electrical and mechanical engineering; age 39 years.—Address, P6527, The Engineer Office. P6527 B

Edward Arnold & Co.'s Book List.

RAILWAY ELECTRIC TRACTION.

By F. W. CARTER, M.I.E.E.,
British Thomson-Houston Company, Rugby. 400 pages, with 204 Diagrams, Photos and Plates. 25s. net.

The author starts with a survey of the different systems of electrification and draws a comparison between steam and electric working under various conditions. He then describes the locomotive, distribution systems, etc., in detail, and develops the mathematical calculations necessary for dealing with the various problems which arise.

Nature.—"The book can be recommended to the traction engineer, who will find not only a good account of the most modern practice, but also many original dynamical discussions which have a direct bearing on his every-day work."

Times Engineering Supplement.—"Likely to make the strongest appeal to the designer, and particularly, perhaps, to the designer of electric locomotives, although the whole ground of electric railway work is well covered. The book is one that every engineer concerned with electric traction will find interesting."

SURVEYING.

By W. N. THOMAS, M.Sc., A.M.Inst.C.E., Demonstrator in Engineering in the University of Oxford. viii + 530 pages. 31s. 6d. net.

The Engineer.—"It may be recommended as being at once sufficiently elementary, theoretical, practical and advanced to be both a sound text-book and useful book of reference."

THE THEORY OF MACHINES.

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Engineer.—"This is a very good text-book, very ably written and carefully illustrated."

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By S. W. PERROTT, M.A.I., M. Inst. C.E., Professor of Civil Engineering in the University of Liverpool, and F. E. G. BADGER, A.M. Inst. C.E.
303 pages, many Diagrams. 30s. net.

PROPERTIES OF STEAM & THERMO-DYNAMIC THEORY OF TURBINES.

By H. L. CALLENDAR, F.R.S., Professor of Physics in the Imperial College of Science and Technology. 544 pages, numerous Diagrams. 40s. net.

"It is safe to say that the present work will take its place at once as the standard treatise on the subject."—*The Times Engineering Supplement.*

London: EDWARD ARNOLD & CO., 41 and 43, Maddox St., W. 1.

SITUATIONS WANTED (continued)

SUPERINTENDENT, Thoroughly Capable, Practical engineer, good disciplinarian and organiser, expert on marine engineering and general machine shop work, tool and jig design and latest methods of rapid production, SEEKS ANOTHER BERTH with more scope for initiative; highest references; age 42.—BARTON, 75, Albert-road, South Norwood. P6551 B

WORKS MANAGER, Steel Tube Works, REQUIRES SIMILAR APPOINTMENT or Assistant to Director; conversant with modern methods, seamless and welded tubes, American and British practice.—Address, P6550, The Engineer Office. P6550 B

YOUNG MAN SEEKS POSITION in Engineer's drawing-office as beginner; constructional preferred; technical education, knowledge of French and mechanical drawing; studying for A.M.I.M.E.—Address, P6554, The Engineer Office. P6554 B

PARTNERSHIPS

ENGINEERING PARTNERSHIPS AND BUSINESSES.

Wheatley Kirk, Price & Co.,
46, Watling Street, London, E.C. 4.

Established seventy years.

ENGINEER, Age 35 (Public School Man), with first-class practical and commercial experience at home and abroad, DESIRES PARTNERSHIP or DIRECTORSHIP in sound progressive engineering or merchant business. Capital available £3-4000.—Address, P6518, The Engineer Office. P6518 C

LONDON MOTOR ENGINEERING CO. REQUIRE ROAD SALESMAN, open agencies, £5 weekly and commission; COMMERCIAL MANAGER, £350 p.a., investment £1000; ASSISTANT MANAGING DIRECTOR, with seat on board, £450 p.a., investment £1500. 300 orders awaiting execution; good dividends can be relied on.—Apply, Messrs. TITCHFIELD, 39, Great Titchfield-street, Oxford-circus, W. 950 C

PARTNERSHIPS and DIRECTORSHIPS WANTED (not under £2000) by fully qualified men. Businesses must be well established.—OFFICERS' PARTNERSHIP GUARDIAN, new address 49, Dover-street, London, W. 1. 904 C

TO MANUFACTURERS, ENGINEERS, AND OTHERS.—Advertiser, sole owner of valuable patents in the motor and aerial world; also has protected syndicate, £15,000.—Apply, M. INST. C.E., Beaucleuch House, Westcliff. P6563 C

PATENTS

INVENTIONS DEVELOPED, PATENTED, and SOLD for Clients by Engineers (late of Victors Ltd., B.Sc., M.E. Ass. R., A.M.I. Ae. E.). Strictest confidence, most moderate terms.—FORTIS and PARTNERS, 60, Queen Victoria-street, E.C. 4. Tel., Cent. 3864. 942 B

THE OWNER of PATENT No. 141,001, for "Improvements in and relating to CONTINUOUS VACUUM FILTERS," DESIRES to LICENSE or SELL the PATENT RIGHTS in Great Britain.—Address, E. P. ALEXANDER and SON, Chartered Patent Agents, 306, High Holborn, London, W.C. 1. 906 B

THE PROPRIETOR of LETTERS PATENT No. 138,071, relating to—

"METHODS of WELDING CHAIN LINKS,"

DESIRES to DISPOSE of his PATENT or to GRANT LICENCES to interested parties on reasonable terms with a view to the adequate working of the patent in this country.

Inquiries to be addressed to—

CRUIKSHANK and FAIRWEATHER,
65-66, Chancery-lane, London, W.C. 2. 879 B

AGENCIES

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For continuation of For Sale Advertisements see page 3.

Coal Wharf and Machinery of the North-Western Fuel Company of America.

No. I.

A NEW coal pier or coal wharf for railway, steamship and cart service, built at Duluth, on Lake Superior, by the North-Western Fuel Company, provides for the receiving, shipping, screening and storage of both anthracite and bituminous coal in large quantities at very low cost by the extensive use of machinery. The total storage capacity is about 600,000 gross tons. This company has now six coal piers at this port, with an aggregate storage capacity of about 3,000,000 tons.

The three views given on page 608—Figs. 2, 3, and 4—show the general arrangement of the new pier and its equipment. Fig. 2 is a view looking from the shore end to the head of the pier. The travelling gantry or bridge, with its coal-handling grab bucket, spans the whole width of the pier. Fig. 3 is a somewhat similar view from the head of the pier, with the gantry bridge standing over the shed for anthracite storage at the shore end. At the right are the bins from which the coal is loaded into wagons.

Fig. 4 is a side view, with one of the large 600ft. coal steamers lying at the wharf. Between the forecastle, at the extreme left, and the engine-room and deck house at the stern, the deck is composed almost entirely of hatches extending nearly the full width of the hull. At the left of the view is the anthracite storage shed, and at the right is the coal-handling bridge with its extension or apron in raised position. Beyond is the bunkering plant for delivering coal to harbour steamers. The six loading bins will be noted beyond the storage space. Behind them are grain elevators and warehouses fronting on a slip parallel with that in which the coal steamer is lying.

TRAFFIC THROUGH THE "UNSALTED SEA."

One of the striking features of the extensive transportation system of the United States is the carriage of immense quantities of bulk freight through the chain of the Great Lakes, and the development of mechanical apparatus for the rapid and economical handling of this freight at the loading and unloading ports. This chain of lakes, known otherwise as the "unsalted seas," gives a deep-water route of approximately 1000 miles from Buffalo, at the eastern end of Lake Erie, to Duluth, at the western end of Lake Superior. From Buffalo to Chicago, at the southern end of Lake Michigan, the distance is nearly as great. Deep-water channels have been formed in the straits or "rivers" connecting the lakes. The only lockage is at Sault Sainte Marie—commonly known as "the Soo"—on the St. Mary's River, which forms the outlet of Lake Superior.

Although the grain traffic is considerable, the greater part of the lake traffic consists of iron ore downwards bound from ports on the upper lakes and coal upwards bound from ports on the lower lakes. In 1916 the ore movement amounted to 66,658,466 gross tons out of a total of 92,000,000 tons passing through "the Soo" canals. The tonnage passing Detroit was about 110,000,000 tons, as it included the traffic to and from Lake Michigan, which traffic does not pass "the Soo." The largest boats are 660ft. long and carry cargoes of about 15,000 tons. Most of the boats in this service carry ore southbound and coal north-bound.

The upward or north-bound coal traffic is in part for local use in the districts tributary to the ports, but is mainly for distribution by rail through the North-West—which produces very little coal—and even as far as the Pacific Coast. In particular, vast stocks of coal are stored during the summer and autumn to maintain a supply for the great north-west region during the winter.

Mainly, the coal is bituminous and anthracite from the Pennsylvania and eastern fields, together with intermediate grades from the south-eastern fields. This coal is brought north in enormous trainloads to the Lake Erie ports, where it is delivered directly to the steamers. The loading is done by means of large wagon-tipping machines, some of which can unload 100-ton railway wagons at the rate of forty wagons per hour. These machines not only do the work rapidly and at extremely low cost, but they are also designed to minimise breakage of the coal in transfer by causing it to flow in a confined stream rather than allowing it to drop freely into the hold. Although these machines are of different types and sizes, the general arrangement of the coaling plants is similar to that of the coal-loading dock or staith on the Atlantic coast at Norfolk, Virginia, described in THE ENGINEER of April 29th, 1921.

COAL HANDLING AND STORING.

At the receiving ports on the upper lakes extensive provision has to be made, not only for rapid unloading of the cargoes—since the navigation season is open only eight or nine months—but also for storing the coal so as to form a reserve supply for distribution during the winter, since the cost of rail carriage from the eastern coalfields to the north-west region would be prohibitive. Furthermore, extensive and elaborate machinery equipment is required for handling, screening, sorting, grading and shipping the various sizes of stocked coal.

As a rule, the receiving, stocking, preparing and shipping of coal is done on large piers or wharves, which are from 400ft. to 1200ft. in width, and from 1000ft. to 4000ft. in length, having from 21ft. to 26ft. of water alongside. Unloading machines of different types are used. The latest coal pier of the North-Western Fuel Company at Duluth, which is described in this article, is an excellent example of modern methods and equipment for the four-fold purpose of unloading, storing, preparing and shipping coal.

THE NORTH-WESTERN FUEL COMPANY.

Before proceeding with the description, it will be of interest to note briefly the history of this company and its plants, from particulars given in a paper by Mr. G. H. Hutchinson, chief engineer for the company. Although coal shipping on the Great Lakes dates back to 1855, very little of it went as far as Duluth, at the extreme westerly end of navigation. The possibilities of supplying coal by water for distribution throughout the growing country of the north-western states were foreseen by Mr. E. N. Saunders, and he started a sailing ship service to Duluth in 1871, carrying about 3000 tons that year. The business soon became too large for him to handle alone, and in 1877 the North-Western Fuel Company was organised, with Mr. Saunders as president and general superintendent. His son, Mr. E. N. Saunders, jun., is now president of the company.

At that time—1877—the unloading of the coal vessels was done by wooden buckets or tubs, which were loaded by men in the ship's hold. These buckets were attached to hoisting tackle, the ropes being led either to hand winches or to whip hoists operated by horses. The coal was dumped from the buckets into wheelbarrows, which were wheeled on plank runways extending from the ship's side to the stock pile. In 1878, small steam derricks with ½-ton steel tubs were introduced, and loaded the coal into small tip wagons. In 1887, a group of portable or travelling hoists was installed, each with a ½-ton tub delivering the coal to a side-tip wagon operating on an incline. The loaded wagon running down the incline to the stock pile was attached to a cable which raised a counterweight for pulling the empty wagon back to the ship.

In 1901, the first electric coal-handling plant ever built, as stated by Mr. Hutchinson, was erected for this company by the Brown Hoisting Machinery Company. There were four unloader towers with 1½-ton grab buckets and three travelling gantries of 155ft. span with 43ft. cantilever extensions. Coal taken from the ship's hold by a grab bucket was dropped into a 15-ton hopper in the tower. From this hopper it was fed to a 7-ton bucket on a platform wagon which carried it within reach of the hoisting trolley on the gantry. This plant could unload a 5000-ton cargo in less than ten hours, the coal being stacked to a height of 30ft. on a pier 560ft. wide and 1100ft. long.

An unloading plant for anthracite, with covered storage for 200,000 tons, was installed in 1906. The coal was unloaded by 3-ton grabs on electric hoists, and was distributed over the stock pile by chain-flight conveyors. Beneath the stock pile was a conveyor tunnel, having roof gates through which the coal was fed to flight conveyors.

In 1909, the company installed its first electrically operated gantry, with which the handling of the coal in unloading, stocking, screening, reclaiming and loading was all done by the bucket of the travelling hoist on the bridge of the gantry. A hinged extension of this bridge served to carry the bucket out over the ship. The bridge had a span of 363ft. 6in., and a total length of 455ft. 6in. Its hoisting trolley carried a 5-ton grab, and all movements were controlled by the operator riding on the trolley. A similar but larger plant erected in 1913 had a travelling bridge of 550ft. span and 712ft. total length, handling a 12-ton grab and stocking coal 50ft. high on a dock or pier 610ft. wide and 750ft. long. This plant, with two men on the bridge, can unload a 10,000-ton cargo in twenty hours, and it has unloaded 7000 tons in ten hours' working time.

THE NEW COAL WHARF.

This brings us now to the new coal wharf and machinery equipment noted at the beginning of this article, and of which views are shown in Figs. 2, 3 and 4. This wharf is 500ft. wide, and occupies the greater part of a pier 700ft. wide and 1765ft. long. On one side is a slip with berths for the coal steamers,

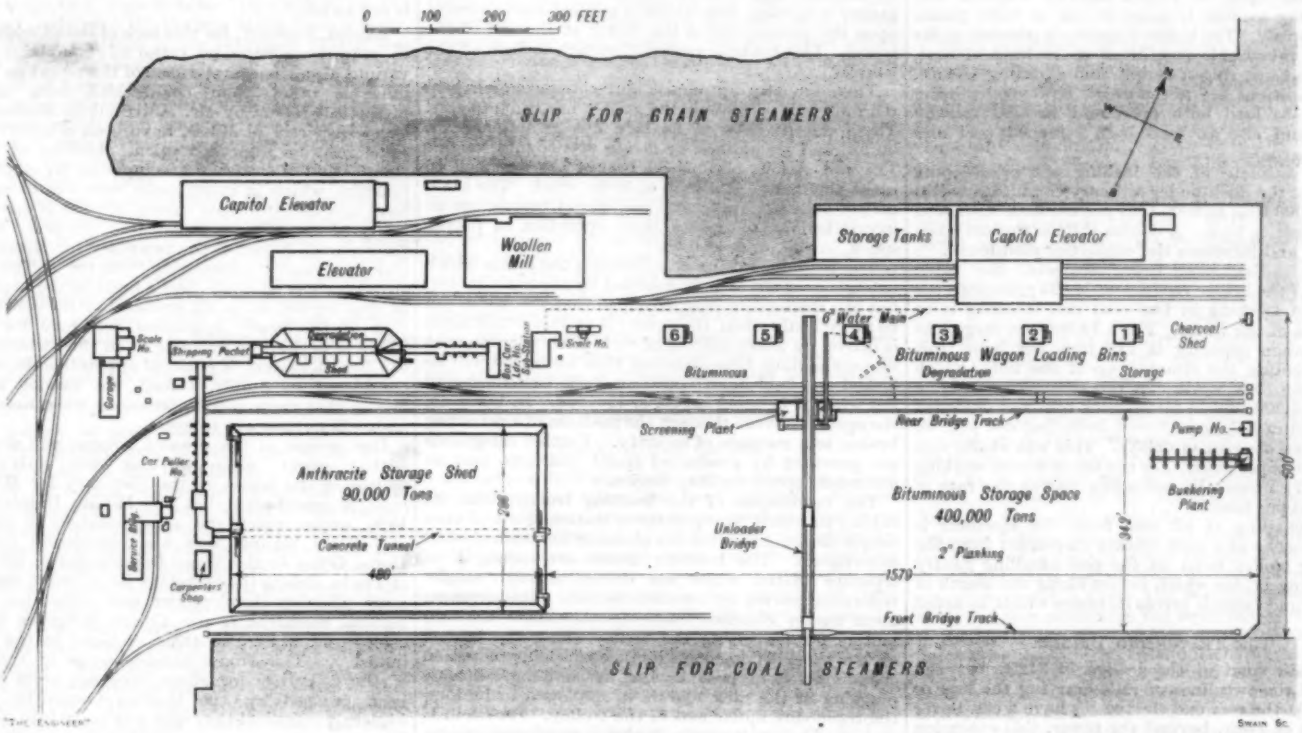


FIG. 1—GENERAL PLAN OF THE COAL WHARF AT DULUTH

and on the other side is a slip for steamers at the grain elevators along the narrower portion of the pier. This pier projects into Superior Bay. The coal wharf has a berth length of 1590ft., with 26ft. of water alongside. The general plan—Fig. 1—together with the three photographic views, clearly explains the arrangement of the pier and its coal-handling and storing equipment.

The gantry bridge already mentioned traverses this wharf on rails parallel with the berths. The bridge has a central span of 342ft. over the stocking floor, and has a total length of 572ft. On it runs a hoisting trolley with 10-ton grab buckets. All movements are controlled by the operator in the cabin of the trolley. The outer portion of the wharf forms an open storage area of 500,000 tons of bituminous coal, while at the inner end is a timber shed with capacity for 100,000 tons of anthracite. Along the rear side of the steerage space are railway lines for coal wagons to be loaded; and a driveway with a row of large bins for loading carts or motor trucks with coal of different kinds for local distribution.

It is difficult to state definitely the capacity in tons shipped out daily, since the output is dependent upon a variety of conditions. However, the rated loading capacity per ten-hour day is 2000 tons of anthracite shipped in box cars or railway covered wagons, 1000 tons of anthracite loaded into carts and motor trucks for local distribution, 1000 tons of bituminous coal loaded into carts and motor trucks, and 2000 to 6000 tons of bituminous coal loaded into open railway wagons. This wide range of capacity for the bridge equipment handling bituminous coal is due to the conditions with different kinds of coal. That is, whether run-of-pile or screened coal, whether loaded into open or closed railway wagons, and whether the loading is done at one or both points simultaneously. The higher capacity is possible under the most favourable conditions as to kind of coal, type of wagons, wagon supply and shunting service. These conditions are not normal, however, it being necessary to load both open and covered railway wagons, and also to load both screened coal and run-of-pile coal.

A fair estimate of the loading out or shipping capacity of the dock under ordinary conditions would be from 4000 tons to 6000 tons per ten-hour day, with a single shift or turn. A double shift is worked when necessary and increases the capacities mentioned.

For unloading coal from steamers, the rated capacity of the bridge equipment is 625 gross tons per hour when working in free coal and stocking it at the middle of the wharf. For a 10,000-ton cargo, the rated average capacity is 425 tons per hour, this figure including the cleaning up of the hold, which is relatively slow work. In the summer of 1921, a cargo of 13,300 tons of bituminous coal was unloaded in a period of 28½ gross hours, including one hour of time lost on account of delays. This was at the rate of 466.6 tons per hour. For the net or actual working time of 27½ hours, the unloading was at the rate of 483.6 tons per hour.

The unloading of all coal from the steamers is done by means of a grab bucket suspended from the traversing trolley hoist on the coal-handling gantry or travelling bridge which moves along the length of the wharf and extends across its entire width, as noted already.

The Traversing Bridge.

The main span of the bridge is 342ft. between centres of the two lines of rails carrying the legs or towers. At the rear end the trusses have a cantilever projection of 140ft. beyond the tower, this extension carrying the rails of the traversing trolley over the railway lines and roadway, so that coal can be loaded into wagons. At the front or water end of the bridge is a 90ft. hinged apron which can be lowered to a horizontal position to enable the traversing trolley to carry the grab bucket out over the ship's deck hatches. When not in use, this extension is raised to a vertical position so as to clear the masts of vessels moving to and from the berths. Thus the total length of the gantry bridge is 572ft., with a travel of 526ft. for the hoisting trolley. The bridge itself has a travel of about 1500ft. along the wharf, and is moved at a speed of 50ft. to 75ft. per minute. The rails carrying the trolley are 75ft. above the floor of the wharf, and the coal can be stacked upon the wharf to a height of nearly 60ft.

When working in free coal, or coal in such quantity that the bucket can take a full load without difficulty, this bridge plant has a capacity for unloading 625 tons per hour. The bucket is hoisted at a speed 200ft. per minute, and is traversed along the bridge of the trolley at a speed of 1000ft. per minute. Grab buckets of two sizes are used. The 10-ton bucket for general unloading is 6ft. 6in. wide, and has a spread of 22ft. when fully open. For cleaning up the cargo a 6-ton bucket is used, 12ft. wide and having a spread of 24ft.

To increase the speed and efficiency of working, the operator on the trolley can revolve the bucket horizontally in the hold of the ship so that it can be spread lengthwise of the hold in order to get a good load, and can then be returned to its normal position for hoisting through the hatch. In the large steamers built specially for the coal and ore traffic the hatches extend almost the full width of the deck and form a series of openings over the entire length of the hold, these openings being interrupted only by the cross girders and frames which tie the sides of the hull together and carry the coamings of the hatchways. The hatch covers are removed and replaced usually by mechanical apparatus operated from steam winches.

The unloader bridge or gantry is mounted on twenty-five flanged wheels 30in. in diameter. Eight of these wheels are under the tower at the front of the wharf, and seventeen are under the rear tower. All the wheels are drivers, being operated by gearing from a single 200 horse-power motor mounted over the front tower of the bridge. Shafting extends along the bridge and down through the towers, being fitted with the necessary spur and bevel gears and universal couplings. Both ends of the bridge are moved simultaneously as a rule, but provision is made for moving only one end if necessary, in order that the bridge may be squared up with the rails in case it should get slightly out of alignment during operation. For this purpose the gearing of the rear tower may be made inoperative by means of disconnecting clutches, so that this tower will remain stationary while the front tower is moved, shifting the bridge through a slight horizontal angle.

Graduated speed of travel of the gantry is provided by means of shunted armature connections in order to permit of slowing down the speed as the gantry approaches the ends of its lines of rails. This avoids shocks from the application of the brakes, and also provides for safety when the bridge is travelling during high winds. As a further element of safety in this last case, there is an automatic cut-out which shuts off current from the main motor when the gantry travel exceeds a certain speed limit. The traversing mechanism is equipped with a normally set solenoid brake, which has to be held off when the gantry is moving, but which is applied automatically upon the cutting out of the motor at the end of the travel. This brake is powerful enough to lock all the wheels.

There are also automatic rail clamps which grip the four rails as soon as the gantry has come to rest. These clamps have to be held out of action by a motor, and are applied by means of a counterweight. The rail clamps and wheel brakes are designed to make the gantry stable in a 50 lb. wind. The main motor, solenoid brake and rail clamp motors are so interlocked as to ensure their operation in proper series, in the order named.

The hoist for raising and lowering the apron which extends over the ship is operated by the main motor, but the mechanism is so arranged that the apron can be moved only when the gantry is at rest. This hoist is driven by worm gearing of such pitch as to prevent its overhauling, thus ensuring that the apron will be locked and held in any position if the current should fail while it is being raised or lowered. In lowering, the apron is driven through the medium of a retarding brake, as a measure of security. Further safeguards are provided by graduated speed cut-outs, and an automatic speed-limiting device.

The mechanism of the hoisting trolley, with its cabin—in which the operator is stationed—is of very simple design, but gives the operator full control of all movements. The hoisting drums are mounted on separate shafts, which are driven through single-reduction gearing by separate motors. This arrangement makes clutches unnecessary. There are two motors for traversing the trolley along the bridge, each of them driving one axle through single-reduction gears. Solenoid post brakes in combination with plugging of the rack motors is employed in braking the traversing movement of the trolley. Provision is also made for dynamic braking supplemented by solenoid brakes for use as desired for the several other operations. As the bridge travel controller is placed on the trolley, the operator can move the bridge along the wharf with the trolley in any position on the bridge.

Master control is used throughout; on the bridge, the bucket handling trolley, and the coal screening plant on the bridge, and for nearly all the motor drives of the apparatus on the wharf. All the bridge motors are operated by 550–600-volt continuous current. For bridge lighting, except in the operator's cab on the trolley, this current is stepped down to 110 volts by means of a continuous-current motor generator set, in order to avoid installing lamps in series. In the trolley cab, however, series coupling is used to avoid a complicated conductor system.

Collector shoes attached to the lower part of the rear tower take the current from conductors laid parallel with and above the rails. Each shoe is in two sections to ensure ample contact at all times. These conductors consist of two rows of steel angles 4in. by 4in. by ⅝in., the angles being mounted on short posts. Provision is made for reinforcing the angles by stranded copper feeders if necessary. This coal-handling bridge, with its operating machinery, was built by the Brown Hoisting Machinery Company, of Cleveland, Ohio.

Upon the rear tower of the bridge is installed an elaborate equipment for screening and sorting the bituminous coal and loading the various sizes for shipment. This apparatus will be described later. The principal functions of the bridge and its coal-handling machinery are as follows:—(1) The unloading of all coal—bituminous and anthracite—from ships; (2) placing the bituminous coal on the stock pile or delivering it directly to the screening plant; (3) placing the anthracite coal in the storage shed; (4) reclaiming bituminous coal from the stock pile and delivering it to the screening plant; (5) screening the coal and grading it to numerous sizes for the market; (6) loading coal into railway wagons for shipment; (7) delivering coal into large bins from which carts and motor trucks are loaded for local supply; (8) re-sorting the degradation or fine undersize coal produced in handling.

Our Mineral Statistics.

Under the above heading we have now for a considerable number of years given a review of the "Mines and Quarries General Report and Statistics, Part III., Output," issued by the Home Office. Our last review was for the year 1920, and it was addressed by the Chief Inspector of Mines to the newly appointed Secretary for Mines. The report now before us takes quite a new form, and is entitled *First Annual Report of the Secretary for Mines for the year ending 31st December*, 1921, *and the Annual Report of H.M. Chief Inspector of Mines for the same period, with a Statistical Appendix to both Reports.* Instead of having the report issued in three parts dealing with distinct subjects, we have now the one report, price 6s. 6d., in which those who are interested only in the output of minerals will continue to find the very restricted details, the presentation of which was adopted as a war time measure. We were hoping that a return would be made to the detailed form in which Part III. was issued prior to 1915, but it would seem that that is not to be.

Except, however, for this lack of detail with regard to output we have no cause of complaint as the various alterations in the form of the report as regards minerals other than coal, which were initiated in the last report by Mr. Mottram, on succeeding as Chief Inspector of Mines, have been retained and in some respects improved upon. Instead of a mere compilation of statistics accompanied by stereotyped remarks, which in many cases were out of date, we have now an up-to-date survey of what is going on in many of our mineral industries. Further, we have the separate report of the Secretary for Mines, which contains much interesting matter. The Chief Inspector has no doubt had a hand in the production of this report, as in all probability he will have in that of the newly appointed Secretary for Mines. There is nothing to grumble at in this, which, under the British system of political appointments, must be considered inevitable, though we cannot avoid a feeling that there will be occasions when master and man will not see eye to eye.

Our review of the present volume will deal only with "output," as in previous years, with the new feature of the report of the Secretary for Mines. It may be mentioned that the Mining Industry Act, 1920, under which the administration of the Coal and Metal Mining Acts was transferred from the Home Office to the Mines Department of the Board of Trade, directs the Secretary for Mines to secure the most effective development and utilisation of the mineral resources of the United Kingdom and the safety and welfare of those engaged in the mining industry. This comprehensive scope of the duties of the Secretary for Mines does not seem to have been grasped by the Geddes Committee, which evidently imagined that coal only came into question. The Committee's report advised that as the mines had been returned to the owners, the Mines Department might as well be given up, and that the functions which had been gathered from various Ministries might revert to those Ministries. So far this advice has not been acted upon, and we hope it will not be, though recently a new assault has been made upon the citadel in the interests of economy. It is advisable, therefore, for those who are convinced of the importance of the Department to be alert in view of further attacks.

Although the county summaries of the output of minerals from mines and quarries are given as of old, elsewhere in the report we find the minerals classified under certain headings for convenience of reference and comment; thus: Coal; iron ore and ironstone; non-ferrous metalliferous ores; minerals used in the chemical and allied industries; minerals used in building and road making and all other purposes; and lastly, oil shale. No doubt some difficulty was experienced in making this classification, as there are cases in which a mineral falls under more than one heading. Where the boundary line could be drawn between "an industry allied to a chemical industry" and one included in "all other purposes," we confess we do not know, but we are not going to indulge in carping criticism on what is undeniably a difficult task. We may perhaps, however, mention one mineral—limestone—which is referred to under the head of building, road-making and iron-making materials. The stone is not used to a very great extent in the chemical industry, but in the form of burnt lime it is largely used. It is stated that in normal years the limestone used as flux is about half the total production in that industry, the "that" referring to basic steel furnaces. This, the second paragraph on page 29, obviously requires a little editing, as the

use of limestone as a flux must refer to iron smelting in the main.

THE OUTPUT OF MINES.

The Secretary for Mines report gives an account of the circumstances connected with the disastrous coal strike of 1921, and although general trade conditions were also bad, it is clear that many other mining industries apart from coal itself were adversely affected by the lack of coal. Except in the case of gypsum, the output of which was almost maintained at 264,840 tons, and sulphate of strontium, which showed a rise, every mineral shows a decreased output, reflecting the bad condition of trade generally throughout the year. Compared also with regard to values, we note that the grand total, including the largest item, coal, amounted to £231,681,358, against £427,444,884 in 1920, and £160,112,811 in 1913, before the upward trend of prices began in the war period. In the bulk of cases, such as iron ore, limestone, barytes, and fluorspar, the diminution in output merely reflected a decreased demand, while in other cases, strikes, lack of coal, or poverty of ground were the dominant adverse influences. During 1921 there were in the United Kingdom 3045 mines working under the Coal Mines Act; 385 metalliferous mines under the Metalliferous Mines Regulation Acts; and 5466 quarries under the Quarries Act, 1894; and it is pointed out that while the Coal Mines Act is a modern affair having been brought up to date in 1911, no attempt has been made in recent years to consolidate the enactments relating to metalliferous mines and quarries. It is recognised that action in this respect is overdue, and the Advisory Committee for the metalliferous mining industry appointed under the Mining Industry Act is now seriously considering what are the best steps to take. In a special part of the report, entitled "Oil Borings in the United Kingdom," it is stated that in the course of 1921 it was decided that operations under the agreement with Messrs. S. Pearson and Sons, Limited, should be stopped as far as possible, and no further drilling be undertaken by the Government. The only Derbyshire well to give a yield of any importance was the Hardstoft, the yield of crude oil being 342 tons against 375 tons in 1920. The natural flow of the oil under its own pressure is about 3 tons per week, the total production from the commencement of flow being 932 tons up to the end of 1921. Mention is made of the interesting occurrence of a great thickness of volcanic rocks met with on the top of the millstone grit at the Apedale boring in North Staffordshire, as no such deposits had previously been known at that horizon in the Midlands. In Scotland the only boring still in progress is that at D'Arcy, near Dalkeith, where oil was struck last May at a depth of 1810ft.

COAL.

The output of coal totalled 163,251,181 tons, against 229,532,081 tons in 1920, the strike being the main cause of the diminution. Some of the deficiency, of course, was made up by the imports of American gas coal, and with regard to this matter, which does not really concern these statistics, we shall only remark that we are hardly likely to buy this coal except when home supplies fail. America has certainly very good gas coals, but a good deal of the business we did in 1921 was concerned with what was not of the best quality. The amount of coke obtained in coke-oven plants of all kinds was 4,575,618 tons, against 12,611,435 tons in 1920, the closing down of blast-furnaces being the main cause of this great reduction. The coke produced at gasworks was 6,798,492 tons, against 8,307,141 tons in 1920, a considerable fall, seeing that public service supplies do not usually rise and fall in times of trade depression. Of course, the coal strike led to a considerable decrease in the supply of gas, though, as we have said, we were helped through by American coal, the coke from which may or may not be included in the figures given. It is not always possible to get complete statistics of any material under the stress of abnormal circumstances, and no attempt has been made to estimate the tonnage of coal extracted by miners from outcrops during the strike. The briquette manufacture in 1921 was affected seriously by the coal strike, and the fall in the price of pitch was largely discounted. The tonnage of briquettes produced in the United Kingdom was 1,064,204, less than half that in 1920. Glamorgan remains, as of old, the principal producer, and steam coal slack continues to be the principal raw material. The return by the Board of Customs and Excise relating to the export is not given, but we may assume that the great bulk of the output is exported to several countries, the principal buyers being Italy, France, Spain, Algeria, and Mexico.

Turning now from the general to the particular, we shall refer to some of the more important or interesting minerals, taking them, for the sake of convenience, in alphabetical order. On former occasions we have commented on the increase or decrease of output from particular districts or mines, but this time, in view of the adverse conditions affecting the mining industry generally, it seems somewhat ungracious to emphasise the decreased outputs, which are almost universal, and which we all hope and expect will prove to be a matter which only concerns 1921 and 1922.

ARSENIC AND BARYTES.

Arsenic—presumably arsenical pyrites and crude arsenous acid—was produced to the amount of 1032 tons as a by-product of Cornish tin mining, and no doubt the steps which are now being taken to revivify the tin mining industry will be reflected in a larger production of arsenic, although competition from abroad is more severe to-day than it was in past times. The barytes output at 24,669 tons does not compare at all well with that of recent years. No doubt it will soon be increased again, as the exploratory work done by the Geological Survey in the war years proved the existence of ample reserves. For 1921 there were returns from fourteen counties against sixteen in 1920, Shropshire, the largest producer, with 6935 tons, being followed by Cork, with 4516 tons, other producers in order of merit being Derby, Devon, York, Montgomery, Westmorland, and Durham. This list shows great changes from what was the case a few years ago, when Durham was easily first instead of eighth. A very prominent reduction is that reported of Northumberland, where the Settlingstones mine yielded 806 tons, against 3585 tons in 1920. This mine yields only witherite, the carbonate of barium, and is the largest producer of this mineral in the world in normal times, the amount in 1909 being nearly 10,000 tons. How far the reduced yield of 1921 is attributable to trade depression we do not know, but we believe that synthetic carbonate is now being made from the sulphate of barytes, and this can hardly fail to affect the mining of witherite. Another prominent case of decreased output is in the recently reopened mine on the Gass Water Vein in Ayrshire, the total being 305 tons against 4574 tons in 1920. With regard to the great falling off in the Durham output, it may be mentioned that the principal mine, the New Brancepeth, is in the coal measures, the barytes, in fact, occurring in conjunction with coal and being wound from the same shaft as coal. The coal strike would therefore mean a complete stoppage. In Devonshire, on the other hand, the barytes is all quarried, and a coal strike is a matter of unconcern to the management. With regard to values, we note that the average net selling value of the mineral at mine or quarry is given as £3 4s. 9d. in 1921, against 16s. 10d. in 1913, or about four times as high. These figures must not be read too closely, because they are only comparable to some extent, on account of much of the barytes now being sold from the mines being of a higher degree of fineness and purity than was the case before the war; also a much higher tonnage of the carbonate valued at four times the figure for the sulphate appeared in the 1913 returns than in the 1921 returns. However, the main point is that the price now being obtained is much higher than it was, and that mining is a more profitable undertaking, though not as profitable as it would be if the mine-owners' desire to exclude imports materialised.

BAUXITE AND COPPER.

Bauxite, a hydrate of alumina containing a good deal of iron and silica, has been regularly obtained in Co. Antrim as a decomposition product of volcanic rocks. Something in the nature of the difficulty which has long existed with regard to deciding whether the tomato is a fruit or a vegetable has probably been experienced by the compiler of these statistics with regard to the classification of bauxite. It is an earthy mineral, and the best qualities are used as a source of metallic aluminium. Seeing, however, the uses to which the bulk of the Irish output is put, it would figure more correctly under the head of minerals for chemicals and allied industries than under that of non-ferrous ores, where we find it alongside of lead, tin and zinc concentrates. For our aluminium industry the main supplies of bauxite come from the South of France, where the mineral is very free from iron and silica.

Copper ore would hardly deserve mention except from its associations with the past, when the Welsh and Cornish outputs ruled the copper markets of the world. The grand total of dressed ore for 1921 was 36 tons, derived from Co. Cork, this being the first occasion on which Irish copper has figured at all prominently in these statistics. Copper precipitate from old mine workings was produced as usual in Anglesey, Devon and Cornwall to the amount of 100 tons, a lower figure than usual. Copper mining has, of course, been very much on the downgrade for many years, and its revival seems improbable except in Cornwall, where prospective developments in tin mining may give it a fillip should the present low price of the metal show an improvement.

FLUORSPAR.

Fluorspar, the sale of which is largely dependent upon the iron industry, was naturally mined to a reduced extent in 1921. Derbyshire supplied 12,357 tons, Durham 10,156, and Yorkshire, a comparatively new comer, 624 tons. Only a small amount is now being got from the old lead mine dumps in Derbyshire, mines and quarries being the principal producers. It is noteworthy that the district in Derbyshire, which for some years has had the largest yield, has recently experienced a serious failure of the mineral, and an important mine has been closed. Developments in other parts of the lead mining field are in progress, but we take it that the proved reserves in the Weardale district of Durham will assure this county's position as the principal producer in the near future. Despite tariffs, our exports to America continue, though interested statements to the effect that the American mines have closed down may be lightly dismissed.

IRON.

Proceeding now to iron, we note a very startling decline in output, the total being 3,477,955 tons, or about one-fourth of our production in normal times. This figure includes hematite of 52 per cent. assay, the liassic ores of Cleveland and the Midlands averaging 28 per cent., and the coal measure ironstones of 34 per cent. In many districts working was suspended during part of the year, and it is satisfactory to note the re-opening of mines and quarries in 1922. The imports of iron ore were 1,887,642 tons against 6,499,551 in the preceding year. The return by the Board of Customs and Excise giving the details of our imports of iron ore from twenty or more countries does not find a place in this report, but there is no reason to suppose that any change of note has occurred, Spain being the principal source of supply, and Swedish Lapland, with its magnetite coming second at some distance behind.

Iron pyrites was mined to the amount of 3943 tons, being entirely, we presume, coal brasses from collieries. No figures are given relating to imported pyrites, mostly cupriferous. In 1920 the imported ore was 630,564 tons, and in some former years it has reached almost a million tons. Depression in the heavy chemical industry and the existence of stocks reduced the 1921 imports considerably, and now former buyers of pyrites have the opportunity of buying American and Sicilian sulphur at a figure which reduces the cost per unit of sulphur burnt to less than in the case of imported pyrites. This state of affairs will necessarily reduce our pyrites imports as long as it lasts.

LEAD.

There is nothing in the returns for lead for 1921 to cause elation, the output being the very meagre one of 6787 tons, against 24,282 tons in 1913. The small total was due largely to the fall in the price of the metal to about £14 per ton, though other important contributing factors were the coal strike and the miners' strike at Leadhills, Lanarkshire, the neighbouring mine, the Queensberry, in Dumfriesshire, the largest producer in the kingdom in 1920, being also adversely affected. With the rise in the metal to £24 and satisfactory arrangements having been come to with labour in many of the lead mining districts, we confidently expect much better returns for 1922. The Threlkeld mine, in Cumberland, has been re-started, and arrangements have been made whereby that old and steady producer, the Greenside mine, Westmorland, will continue its existence. Developments are also in progress in Derbyshire at the Mill Close mine, which, despite the inundation of the lower levels, produced about 1600 tons of dressed ore in 1921. The outlook in Flintshire, where the Halkyn mine has closed down, is not promising, and, as is pointed out in the Secretary for Mines report, the future of the Halkyn Mountain district depends upon the completion of the new Milwr drainage tunnel, the object of which is to unwater the mines as far as the North Hendre mine below the existing Halkyn tunnel down to which the measures are worked out. From the commencement of the work the new enterprise has been hampered by lack of funds, though some money was advanced during the war by the Ministry of Munitions to the company owning the old Halkyn tunnel to facilitate the draining of some of the mines, with not particularly satisfactory results. Nothing but the completion of the new tunnel scheme in its entirety will be of any real avail in rehabilitating the mining industry of the district, which, an important producer in the past, shows every indication of continuing to yield large quantities of ore when the water trouble has been dealt with. We note with satisfaction that the Mines Department has had conference with the various interests involved and is hopeful that certain difficulties which have operated against the raising of further capital will be surmounted. In Cumberland the old mines of Rodderup Fell and Crosagill are noticeable as producing again, though there does not seem any likelihood of any general revival in the Alston Moor district, once such a large producer of lead.

STRONTIUM.

Strontium, or rather celestine, the sulphate, is very sparsely distributed throughout the world. In this country, the only occurrences of economic value are in Gloucestershire and Somersetshire, where the mineral is obtained from shallow pits in the triassic marl. The output in 1921—all from Gloucestershire—was 6622 tons, a considerable advance on that of the previous year, though not up to the yields of many former years. The principal market before the war was Germany; now America is an important buyer because none has been mined in the States since 1918, the cost of production rendering it impossible to compete with the British. We note that the net selling price at the quarry was 25s. 10d. per ton, against 17s. 5d. in 1920, and 15s. in 1913. Thirty years ago the figure was 40s. per ton, and in the absence of any new discoveries which can be worked so cheaply, a satisfactory price should continue to be obtained.

TIN AND ZINC.

Our space is becoming exhausted, and there is not

much left for reference to tin and zinc. Only 1078 tons of dressed tin ore were obtained in Cornwall in 1921, compared with 8355 tons in 1913, the value being £85 per ton, about half that of the previous year. For some time now it has not been profitable to work the mines, but with the reduced cost of coal and materials and the fall in wages rates, there is good reason to expect a resumption of activity with a small rise in the value of the metal, that is, in mines where it has been found possible to keep the pumps going. The report mentions that the Dolcoath mine, after a life of over 170 years, and having attained the depth of 3000ft., has been abandoned owing to the impoverishment of the main lode. The company, however, remains in existence, and proposes to develop the neighbouring North and South Roskear lodes, which have been formerly worked for copper, but abandoned when the copper gave out and before the zinc zone was reached. Another important development is the new shaft which the East Pool Company is sinking to work the Rogers lode section of its property.

Coming finally to zinc, which in the course of a year dropped from £63 per ton to £24, we note the trifling output of 814 tons, about 5 per cent. of the pre-war production. The report states that there was no market for zinc concentrates during 1921, and that zinc smelting plants, with the exception of Seaton Carew, were at a standstill. Consequently, the report goes on, all British mines the principal production of which is zinc-blende remained closed during the year. With regard to this latter statement, we may mention that prior to the war all the zinc concentrates produced at the important Nenthead mine belonging to the Vieille Montague Company, in Cumberland, went to Belgium to be smelted, and concentrates from Flintshire were often sold on the Continent because better terms were available. In respect of there being no market for British zinc concentrates we might say a good deal regarding the late Government's war contract for the purchase of Australian zinc concentrates and the effect it has had and is likely to have upon our home production. Making due allowance, however, for this factor, our zinc mining has in only few cases proved profitable unless carried on in conjunction with lead mining, and no new deposits of any importance have been opened up for many years. Last year saw the closing down of that famous old mine, the Great Laxey, in the Isle of Man. The immediate cause of the cessation of work was the wages demands made on the advice of imported labour extremists, but the fact that no new lodes had been discovered of late years and the poverty of ore at depth had also a good deal to do with the termination of work. Among the annual yields of zinc concentrates from this mine may be mentioned 4600 tons in 1888, 1685 tons in 1905, and 2025 tons in 1910.

A project is on foot to treat the large zinc ore dumps at some of the old Cardiganshire mines by an electrolytic process, and if it matures and is successful a decided incentive will be given to zinc mining in this country, because in several districts the complexity of the ore has rendered efficient hydraulic dressing an exceedingly difficult problem.

Some Recent Researches on Lubrication.*

By Dr. T. E. STANTON.

The Present Position of the Problem of Lubrication.—The theory of lubrication of Osborne Reynolds, published in 1886, was based on the existence between two lubricated surfaces, of a film of lubricant moving according to the laws of hydrodynamics, and was for long taken to afford a complete explanation of all the phenomena of lubrication. In recent years, however, the inadequacy of this theory to explain all the observed facts in the practice of lubrication has become more and more recognised. The main considerations which have led to a modification of the older view being as follows :—

(1) The discovery that lubrication can exist between surfaces which are so close together that no motion of the lubricant subject to the laws of hydrodynamics can take place between them.

(2) The relative superiority as lubricants of the fixed oils such as sperm, rape, and castor, over mineral oils of the same viscosity.

(3) The marked increase in the efficiency of worm gears, obtained by the addition of small quantities of fatty acids to mineral oils, the viscosity being very little affected by the addition.

(4) The well-known advantage obtained by the use of certain bearing metals.

All these facts appear to be consistent with the existence of a thin film of lubricant of molecular dimensions separating the surfaces, in which case the resistance must depend on the chemical constitution of both the lubricant and the lubricated surfaces. This kind of lubrication has been called "boundary lubrication." Lubrication of the Reynolds' type is here referred to as "perfect" lubrication.

The Range of the Proposed Investigation.—On making a careful examination of the available evidence, it appeared to the writer that there were two directions in which fresh light on the problem might be sought.

In the first place it appeared to be very desirable that the theoretical effect of the use of lubricants of different viscosity in lubrication of the Reynolds' type should be more generally recognised by engineers than is the case at present. Secondly, an extension of the previous experimental work appeared to be very desirable in order to decide whether lubrication of the Reynolds' type was of common occurrence in engineering practice, or, as some engineers are inclined to think, a somewhat rare phenomenon found to exist under the special conditions of the Michell thrust bearing and the bath lubricated journals used by Tower.

Review of the Theory.—The work of Tower, carried out in 1883-1885, first led mathematicians to take up the study of lubrication as a particular problem in fluid motion. Tower discovered that the lubricant at the crown of the bearing was under considerable pressure, and by connecting small holes at different points of the bearing surface to a Bourdon pressure gauge he was able to obtain a rough estimate of the difference of pressure. From the fact that a summation of the vertical components of the oil pressure was approximately equal to the total load, he was able to demonstrate that the two surfaces of bearing and journal were completely separated by an oil film.

This discovery led Osborne Reynolds to take up the problem from the theoretical side and to study the conditions under which by the laws of hydrodynamics a separating film could be permanently maintained between the surfaces such that the pressure distribution in the film would account for the load and the shear stress distribution would account for the frictional resistance actually experienced.

Such a state of motion, he found, could only exist when the following conditions were satisfied :—

(1) That there must be a finite difference between the values of the radii of the journal and the bearing, and that the bearing must be in general excentric to the journal.

(2) That the attitude of the bearing relative to the journal would be as shown in Fig. 1. Thus O is the centre of the journal and O′ that of the bearing. Then evidently the line O O′ produced passes through A, the point of nearest approach of the surfaces. If η be the difference of the radii of the two surfaces, it is evident that O O′ cannot exceed η, and that its value must lie between zero when the surfaces are concentric, and η when the surfaces are touching.

It is usual to write O O′ $= c\,\eta$ and to call c the excentricity, c having any value between O and unity. The angle α which O A makes with the vertical may be called the attitude of the bearing, and when the attitude and excentricity are specified the position of the bearing is fixed.

Under such conditions Reynolds showed that from the laws of hydrodynamics the pressure changes in the film must be given by the equation—

$$\frac{d\,p}{d\,\theta} = \frac{6\,\mu\,U\,a\,c}{\eta^2}\left(\frac{\cos\theta - \cos\theta'}{(1 + c\cos\theta)^3}\right)$$

where θ is measured from O A′ in the direction of rotation of the journal, μ is the coefficient of viscosity of the lubricant, U is the relative speed of the two surfaces, a the radius of the journal, and θ' the value of θ when the pressure is a maximum.

This is the fundamental equation of lubrication from which all succeeding investigators, Michel Petroff, Sommerfeld and Harrison have proceeded. The obvious method of finding whether in the case of Tower's experiments a hydrodynamical state of flow existed, was to integrate equation (1) and compare the pressure so calculated with that actually observed by Tower. Unfortunately this comparison is a matter of extreme difficulty, not on account of the integration itself, but because before the numerical value of p corresponding to any particular value of θ can be calculated, it is necessary to know the attitude, the excentricity, the viscosity of the oil, the radius difference of the bearing and journal, and the angular position of the point of maximum pressure.

The Complete Solution of the Half Bearing.—The difficulties encountered by Reynolds in dealing with the theoretical case of a half bearing in which, owing to high load or slow speed, the distance between the surfaces becomes less than half the difference of the radii of the bearing and the journal, were eventually overcome by Sommerfeld in 1900. Without the aid of advanced mathematics he succeeded in obtaining a solution of the problem of the half bearing for all values of the excentricity. This solution is not entirely applicable to practical conditions in that the falling off of the pressure at the ends of the journal is neglected.

One of the most interesting and valuable of Sommerfeld's results is the relation which he obtained between the attitude and excentricity of a half bearing and what must hold whatever the load, speed and lubricant employed. This relation is shown in Fig. 2, in which the radius vector of the curve gives the displacement of O′ from O and its angular position the attitude of the bearing. It will be seen that, as previously shown by Osborne Reynolds, there are two values of the excentricity for each value of the angular position of the point of nearest approach.

Application of the Theory to a Practical Case.—A still more important application of Sommerfeld's work is the light which is thrown on the effect on the frictional resistance of changes in the lubricant employed in the case of heavily loaded bearings.

In order to show this I have worked out from Sommerfeld's equations the frictional resistances of a 4in. bearing in which the load and speed are always the same and the lubricant alone is varied.

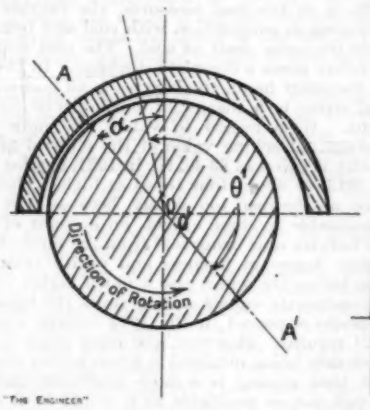


FIG. 1

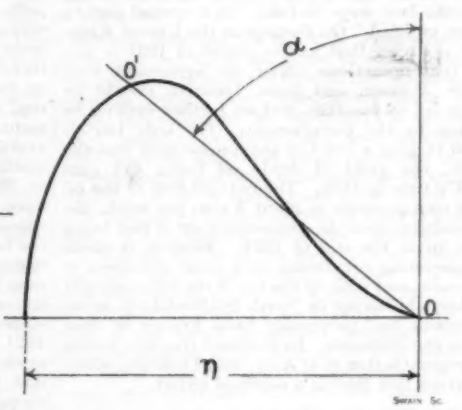


FIG. 2

The results are given in the following table :—

TABLE I.

Diameter of journal .. 4in.
Diameter of bearing .. 4.004in.
Speed .. .. 188 revolutions per minute
Load .. .. 3420 lb. per square inch run

Viscosity of lubricant C.G.S. units.	Attitude of bearing.	Excentricity of bearing.	Nearest approach in inches.	Coefficient of friction.
	Degrees.			
0.223	129	0.94	6×10^{-5}	0.00094
0.488	135	0.82	18×10^{-5}	0.00096
0.824	133	0.65	35×10^{-5}	0.00099

It will be seen that an increase in the viscosity of the lubricant in the ratio of about 4 to 1 has quite a small effect on the frictional resistance the increase in which is of the order of 5 per cent. The reason of the comparatively small effect on the friction is, as will be seen, due to the fact that with the more viscous oil the the surfaces are kept much further apart than with the thinner oils and that consequently the speed remaining the same the product of the coefficient of viscosity into the space rate of shear, which is the frictional resistance, remains nearly constant. This example is a very instructive one in that it clearly demonstrates the insufficiency of the deduction that observations showing that friction is independent of viscosity must be taken as conclusive evidence of the existence of boundary lubrication.

The Lubrication of Flat Surfaces.—It is of interest to note that whatever limitations may be found in practice to the existence of a film of lubricant of the Reynolds' type in cylindrical lubrication, difficulties in the setting up of this condition rarely appear in the case of flat surfaces, for which the theory has been worked out by Michell. In this case, by eliminating the curvature of the surfaces, Michell has been able to obtain the pressure distribution in two dimensions and thus to take account of the leakage at the sides of the plate.

The Experimental Investigation of the Characteristics of Cylindrical Journal Lubrication under Limiting Conditions of Pressure.—In considering the details of the apparatus to be designed for the experiments at Teddington, the first consideration was whether, in view of the difficulties which Reynolds had encountered in the interpretation of Tower's results, some of the unknown factors could not be evaluated experimentally. One of these unknown factors in

* Institution of Mechanical Engineers, Ninth Thomas Hawksley Lecture (abstract), delivered in London, December 1s t

Tower's experiments was the temperature of the oil film. On examination of the possibility, in the present tests, of a direct observation of the temperature of the film, it appeared probable that this could be measured with sufficient accuracy by thermo-electric methods, and it was decided to make provision for this in the design.

A still more valuable asset in the interpretation of the experimental results, if it were possible to make a determination of its value, would be the difference of radii between the bearing and the journal. In 1886 high accuracy in the measurement of the internal diameter of cylinders had not been developed, and it is not improbable that with the best methods available at that time the limits of accuracy of the determination would have been ± 15 per cent. With the aid of modern methods, however, an accuracy of ± 1 per cent. in the measurement of the radius difference could be hoped for, so that as far as the dimensions of the bearing in its unstrained state are concerned the difficulty can be overcome.

It was realised, however, by Osborne Reynolds, that there were two factors in the conditions of running which would materially affect the curvature of the bearing, one the expansion of the metal of the bearing due to the rise of temperature caused by the frictional resistance, and the other the elastic distortion of the bearing under the imposed load, with the result that the value of the radius difference would vary both with the load and the speed.

The amount of these distortions was actually calculated from Tower's results, and for his 4in. bearing was found to involve increases in the radius difference of about 50 per cent. due to an increase of load from 100 to 400 lb. per square inch mean pressure, and 25 per cent. due to an increase of speed from 100 to 450 revolutions per minute. In order to obviate this difficulty it is necessary to increase the rigidity of the bearing and to work with a much larger radius difference so that the effect on the latter of any distortion due to load and temperature is comparatively small.

General Arrangement of the Apparatus.—This is shown in Figs. 3 and 4. The bush, which is of phosphor bronze ground and lapped out to the required diameter is supported in a steel housing by means of ball bearings, thus affording means of independent rotation for the purpose of the pressure observations. The loading is obtained by cast iron flitch plates bolted to the sides of the housing. A small oil dashpot is provided to damp out any oscillations of the bearing, and a scale pan and calibrated spring for measuring the frictional torque. A special feature is the load relieving device by means of which the load is gradually taken off the journal before stopping its rotation, and for the gradual imposition of the load in starting up. The journal which is made of tool steel hardened and ground was overhung and held by a chuck at the end of the driving shaft. The Bourdon pressure gauge for measuring the oil pressure is carried by the steel housing of the bearing and is connected to the pressure hole by soft copper tubing, which could be bent into any desired position when rotating the bearing into the different angular positions of the pressure hole. For the measurement of the temperature of the film an iron-constantan thermo-junction was inserted into a small hole drilled in the crown of the bearing, and in such a position that the junction itself was in contact with the surface of the revolving journal.

Results of the Experiments.—The early experiments on pressure distribution were made with bearings in which the radius difference was about 0.1 per cent. of the radius of the journal. It was realised that under these conditions the effect of temperature and elasticity would probably be such that no reliable estimate of the attitude and distance apart of the surfaces could be made, but it was thought worth while to make them for the sake of obtaining a check on the previous experimental work under similar conditions. On making a series of pressure observations, curves of pressure distribution were obtained from which the resultant vertical component of the oil pressure could be determined by integration. The values of these components were found to be appreciably in excess of the mean load per inch run of the bearing as they should be in view of the falling off of the intensity of pressure at the ends of the bearing. It was evident, therefore, that the perfect state of lubrication obtained by Tower in his oil bath experiments could be easily reproduced in the present apparatus. As these, however, were not the conditions under which the problem was to be studied, the work with the high values of the radius difference was proceeded with, and attention was finally concentrated on a series of experiments with a bearing in which the radius difference was 2 per cent.

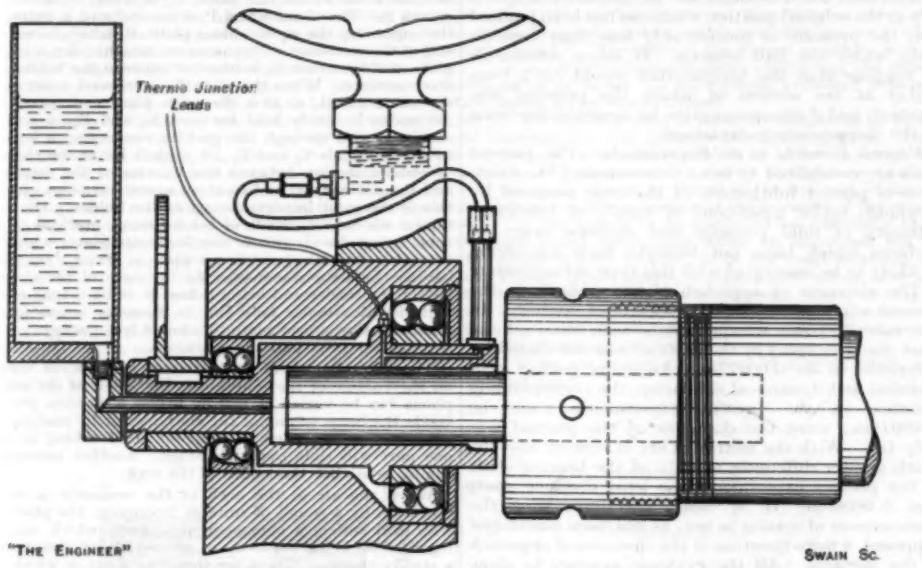


FIG. 3—SECTION OF JOURNAL AND BEARING IN EXPERIMENTAL APPARATUS

The pressure distribution over the central section of this bearing, under a total load of 690 lb. and at a journal speed of 1000 revolutions per minute, is shown in Fig. 5, for the case of sperm oil. As the main object of the experiments was the determination of the attitude and excentricity of the bearing no attempt was made to investigate the extent to which the pressure fell off, in a longitudinal section, towards the ends of the bearing.

The arc of contact of the film over which pressures above atmospheric existed is somewhat restricted, the extent being 30 deg. for sperm oil and 35 deg. for rape. In order to examine whether any appreciable area of the film were under pressures below that of the atmosphere, the pressure gauge was replaced by a vacuum gauge and the region outside the positive pressure area was explored. No evidence, however, could be found of any marked suction effect, and it was concluded that this might be neglected. Further evidence in favour of this conclusion was obtained from an integration of the pressure components in the direction of the load, the result of which, allowing for the falling-off of pressure at the ends of the bearing, was approximately equal to the total load. The values of the observed frictional torques were 0.25 pound-inch for sperm oil and 0.59 pound-inch for rape, giving values of the normal coefficient of friction 0.00072 and 0.0017 respectively.

The results of these experiments were so satisfactory that an attempt was made to obtain still higher intensities of oil pressure by a further increase of the radius of the bearing.

For this purpose a phosphor bronze bush of 1.06in. internal diameter was prepared. Tests were made with this bearing in the same manner and under the same conditions of load and speed as before. As these conditions were severe it was decided to use the best known lubricant for high pressures, and a trial was made with castor oil. It was found that a steady state of lubrication could be set up with this oil and the pressure distribution was determined. This appeared to be quite satisfactory, but it was noticed that although the arc of contact was very much reduced, the intensities of the pressures, although considerably higher than in the case of the 1.02in. bearing, were not sufficient, when their integration was carried out, to account for the total load.

It was thought at first that this was due to some irregularities in the surface of the bearing, and that the discrepancy would disappear after a period of "running in." No improvement, however, was found after a prolonged period of running, and it became evident that this was not the source of the difficulty. The general contour of the pressure curve obtained was so similar to that previously obtained for the first bearing that any explanation based on a change in the lubricating conditions did not seem probable, and the possibility of the central section of the bearing not being that of maximum pressure was examined. Attention was drawn to the fact that the bearing—see Fig. 3—was unsymmetrically supported in the housing by means of the large and small ball bearings, and the possibility of a deformation of the bearing on the two point support thus provided seemed feasible. In order to test this experimentally, a new pressure hole was made in the section of the bearing directly under the main ball bearing, and a new series of pressure observations was taken. Considerably higher intensities of pressure were indicated, which, when integrated, fully accounted for the load. The warping of the bearing under the load was, therefore, fully verified. On the completion of the measurements of the pressure distribution at this section with castor oil as the lubricant, another series of observations was made with the F F F cylinder oil, which was also found to give satisfactory running conditions.

The maximum pressures attained were 3.5 tons per square inch, and an arc of 15 deg. for the castor oil, and 2.8 tons per square inch, and an arc of 14 deg. for the F F F cylinder oil. The coefficients of friction were, however, higher than for the 1.02in. bearing, being 0.0023 for the castor oil and 0.0035 for the F F F cylinder oil.

Prediction of the Attitude and Excentricity of the Bearing from the Pressure Distribution Curves.—After a careful examination of the theoretical relations, it appeared that the characteristics sought might, to the accuracy required, be determined from the fundamental equation

$$\frac{d\,p}{d\,\theta} = \frac{6\,\mu\,U\,a\,c}{\psi^2}\left(\frac{\cos\theta - \cos\theta^1}{(1 + c\cos\theta)^3}\right)$$

In the above equation the two points of inflection

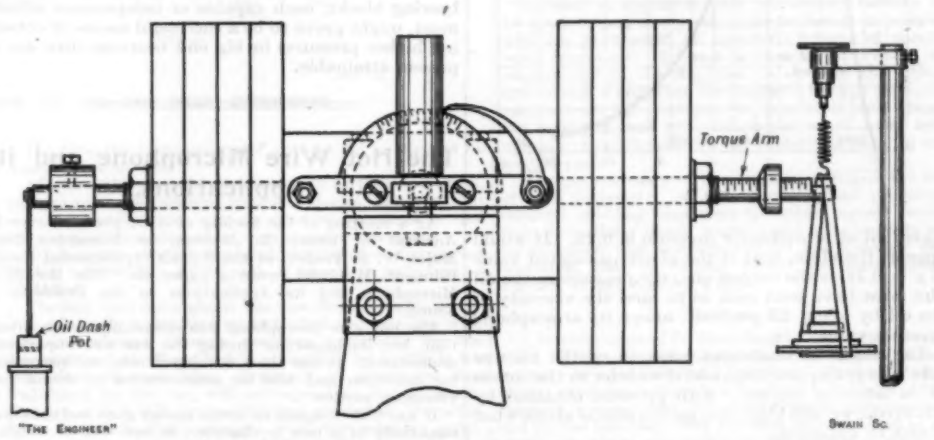


FIG. 4—END VIEW OF EXPERIMENTAL APPARATUS

in the theoretical pressure distribution curve are given by

$$\theta = 180 \text{ deg. and } \cos\theta = \frac{1 + 3\cos\theta'}{2\,c}.$$

The point corresponding with $\theta = 180$, is evidently the point of nearest approach on the off side of the bearing, and it is clear, therefore, that if from the actual pressure distribution curve the point of inflection on the off side could be detected the attitude of the bearing as defined by the angle α would have been determined.

From an examination of the curve—Fig. 5—it will be seen that although this point cannot be located by eye with great precision, the regularity of the observations is such that in all probability it can be located to an accuracy of a fraction of a degree.

The possibility of obtaining an approximate value of the attitude of the bearing from an inspection of the actual pressure distribution curve, suggested the following method of calculating the characteristics of the bearing.

The observed pressures having been plotted on an angle base of which the zero was arbitrary, the position of the point of inflection on the off side was estimated and its angular position was scaled off. In the case of the experiment on sperm oil—Fig. 5—this is seen to be 6 deg. This point, therefore, on the scale of θ, corresponds with 180 deg. The angular position of the point of maximum pressure is seen to be 2 deg. 45 min. behind the point of nearest approach. The angular position of the point of maximum pressure on the scale of θ is, therefore, 180 deg. – 2 deg. 45 min., or 177 deg. 15 min. This gives $\cos \theta^1$ in the fundamental equation. Therefore, given any two values of $\frac{d\,p}{d\,\theta}$ at positions θ_1 and θ_2, we have two simultaneous equations from which the unknown quantites μ and c can be obtained. These values θ_1 and θ_2 are quite arbitrary, but for convenience they have been chosen as 180 deg., the position of the point of nearest approach, and a corresponding point on the "on" side.

In the case of the sperm oil curve—Fig. 5—the scaled values of $\frac{d\,p}{d\,\theta}$ at $\theta = 180$ deg. and 170 deg. 30 min. were found to be – 52,700 and + 13,200 lb. per square inch per radian respectively.

Substituting these values in the fundamental equation :

$$c = 0.9946\,;$$
$$\mu = 0.32 \text{ (in C.G.S. units).}$$

At a temperature of 35.8 deg. Cent., which was the measured temperature of the film the value of μ for

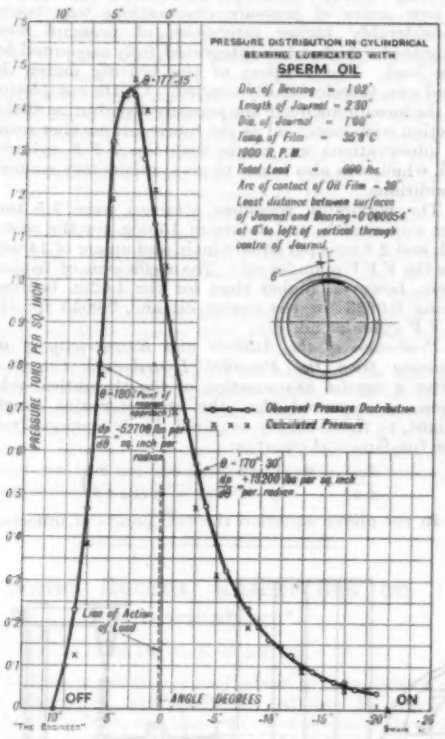

PRESSURE DISTRIBUTION IN CYLINDRICAL BEARING LUBRICATED WITH
SPERM OIL
Dia. of Bearing = 1·02"
Length of Journal = 2·30"
Dia. of Journal = 1·00"
Temp. of Film = 35·8°C
1000 R.P.M.
Total Load = 690 lbs.
Arc of contact of Oil Film = 39°
Least distance between surfaces of Journal and Bearing = 0·000054" at 6° to left of vertical through centre of Journal
θ = 177·15'
θ = 180° Point of nearest approach
dp/dθ = -52700 lbs per sq. inch per radian
θ = 170° 30'
dp/dθ = +13200 lbs per sq. inch per radian
Observed Pressure Distribution
Calculated Pressure
Line of Action of Load
OFF
ON
ANGLE DEGREES
PRESSURE TONS PER SQ. INCH
"THE ENGINEER"

FIG. 5

sperm oil at atmospheric pressure is 0.25. It would appear, therefore, that if the above calculated value of $\mu = 0.32$, is the correct one, the pressure in the oil film must have been such as to raise the viscosity of the oil by about 25 per cent. above its atmospheric pressure value.

The observed maximum pressure of the oil was 1.44 tons per square inch, and if we refer to the curves of variation of viscosity with pressure obtained by Mr. Hyde, we find that such an increase is about what would be expected.

The value of $c = 0.9946$ would appear, therefore, to be approximately correct, and the minimum distance apart of the surfaces can be calculated. This is given by $h = \eta\,(1 - c)$, and is in this case 0.000054in. A similar calculation from the pressure distribution in the rape oil experiments with the same bearing gave

$$c = 0.9904,$$

or, least distance apart of surfaces = 0.000096in.

Following the same procedure in the case of the results obtained with the 1.06in. bearing, the values of the viscosity and excentricity were found to be :—

For the castor oil

$$\mu = 1.14, \quad c = 0.99845.$$

For the F F F cylinder oil

$$\mu = 1.87. \quad c = 0.9978.$$

The values of c in both cases are considerably higher than those for the 1.02in. bearing, but since the radius difference η is now three times greater than formerly, the distance of nearest appraoch $= \eta\,(1 - c)$ is not greatly different, being 0.000046in. for the castor oil and 0.000066in. for the F F F cylinder oil.†

The calculated values of the viscosity are, for the 1.06in. bearing, in each case appreciably less than the experimental values obtained by the ordinary methods at the observed film temperatures which were 1.43 for castor and 2.09 for F F F cylinder oil.

As has been pointed out above, in the case of the 1.02in. bearing, the calculated values of the viscosity were appreciably *greater* than the values at the temperature of the film and at atmospheric pressure, and this was accounted for by the known effect of the pressure in increasing the viscosity.

It is considered that the discrepancy in the case of the 1.06in. bearing is due to the fact that it was not found practicable to measure the temperature of the film at the point at which the pressure was taken, and all that could be done was to measure this quantity at the original position where, as has been pointed out, the pressure is considerably less than immediately under the ball bearing. It seems reasonable to suppose that the temperature would have been higher at the section at which the pressure was greatest, and if this assumption be accepted the cause of the discrepancy is explained.

General Remarks on the Experiments.—The present tests are considered to have demonstrated the existence of perfect lubrication of the type assumed by Reynolds under conditions of supply of lubricant, intensity of fluid pressure and distance apart of surfaces which have not hitherto been considered as likely to be associated with this type of lubrication.

The closeness of approach of the surfaces in the present experiments is also a feature of interest. In the case of Tower's experiments with olive oil the least distance apart of the surfaces was calculated by Reynolds to be 0.00072in. Assuming perfect geometrical and dynamical similarity, the corresponding distance in the present experiments would be 0.00018in., since the diameter of the journal was only 1in. With the restricted arc of contact and the much greater difference of radii of the bearing shaft in the present experiments the least distance apart was 0.00005in. It is clear, therefore, that the phenomenon of seizing is not, as has been sometimes supposed, a mere question of the closeness of approach of the surfaces. All the evidence appears to show that the conditions of lubrication of a cylindrical journal, when they have become steady, are of the Reynolds' type right up to the seizing pressure.

As regards the practical engineering value of the present experiments, the results appear to indicate a possible solution of the problem of the application of the principle of the Michell thrust block to conditions of cylindrical lubrication, which, as far as the author is aware, has not yet been solved.‡

It is fully recognised by designers of internal combustion engines that the chief problem which confronts them in the production of higher piston speeds and consequently greater efficiency is the "big end" problem, *i.e.*, the limit of speed is defined by the limiting pressure on the big end bearing of the connecting-rod. From the success which has been attained in the present experiments in the establishment of very high bearing pressures with arcs of contact of the order of 20 deg., it would appear that a cylindrical bearing constructed of a number of such bearing blocks, each capable of independent adjustment, might prove to be a successful means of obtaining higher pressures in big end bearings than are at present attainable.

† The significance of the figures indicating the distance apart of the journal and bearing surfaces was made clear by Dr. Stanton in a parenthetical remark. Taking the case of castor oil—the smallest of the four—and using an accepted value for the diameter of a molecule of oil, he pointed out that the thickness of the film was equal to 4600 molecular diameters, or quite sufficient to ensure that the lubrication followed hydrodynamical laws and was not of the boundary type.—ED THE E.

‡ In the course of a few remarks after the lecture had been delivered the President, Dr. Hele Shaw, said that the problem of applying the principle of the Michell thrust block to circular bearings was now in an advanced stage towards solution. The position is even more developed, for in our issue of August 29th, 1919, we illustrated and described an experimental journal bearing of the Michell type which had been fitted on the destroyer Mackay.—ED. THE E.

The Hot Wire Microphone and its Applications.

AT a meeting of the Society of Arts, presided over by Admiral Sir Henry B. Jackson, on November 29th, Major W. S. Tucker, of the Signal Experimental Establishment, Woolwich, read a paper on "The Hot Wire Microphone and its Applications to the Problems of Sound."

The hot wire microphone was essentially a war invention, but its behaviour during the war was imperfectly understood. It has since developed into an instrument for detection and also for measurement of sound and vibratory motion.

It was first designed to detect enemy guns and consisted essentially of a box or chamber, in one wall of which a small opening is made. When the explosive wave arrives at this opening—thereby creating a small excess pressure—a blast of air is projected into the box. In the path of this blast a very fine platinum wire grid is mounted, and by means of an electric current the grid is heated to low incandescence. The effect of the blast is then to cool the wire, lower its electrical resistance and so affect instruments such as galvanometers of suitable type that a clear indication of the blast is demonstrated. The blast produced follows faithfully the pressure variations, and these again are dependent on the nature of the source of the disturbance. Hence the record obtained is an indication of the character of an explosion and reveals the fact that heavy explosions consist in the main of very low frequency sounds made up of a highly damped train of waves, and, moreover, reproduces such variations in quality and intensity that they would enable one to identify the source.

The manner in which the grid holder of the instrument is made up is shown in Fig. 1. The cylindrical neck A, which is made of brass, is soldered into the centre of the circular plate E_1, which is made of the same material. The plate E_1 is provided with a terminal T_1. The mica plate M carrying the grid is clamped between E_1 and the lower ring E_2, which is also composed of brass, and carries the terminal T_2 at the side of the holder. Beneath the member E_2 is a rubber ring R_1, which rests on a bed of ebonite P to which the plate E_1 is fixed by means of screws S. The ebonite bed P is square, and is bolted at the corners to the square brass plate B, which forms one end of the container. To ensure an airtight joint a square plate of thin rubber R_2 is inserted between the holder and the container. When the plate E_1 is screwed down on to the ebonite bed, so that the mica plate with silver foil electrodes is firmly held between E_1 and E_2, a current can be passed through the grid by connecting a battery to the terminals T_1 and T_2. A neck A forms the channel of communication between the interior of the container and the outside air, and from an acoustical point of view this is the most important part of the holder. The containers are usually made of brass tubing, one end of the tube being closed with a circular brass plate, whilst at the other end a square brass plate is fitted, this plate having the same dimensions as the base of the ebonite bed of the holder and being bolted to it by means of the bolts *b*. A circular hole ¼in. in diameter is cut in the middle of this square plate to allow a free passage of air through the neck into the container.

The natural pitch of the resonator depends, of course, on the volume of the container. The pitch of the microphone can be varied at will by fitting a wooden plunger inside the brass tubing of the container or by making the container in two parts of different sized tubing so that one part will slide over the other. Another method of tuning is to alter the length of the neck.

When the air in the neck of the resonator is set in vibration by a sound of suitable frequency, the platinum wire grid suffers a change in resistance, which may be regarded as being made up of an oscillatory change and a steady change. There are thus two ways in which the microphone can be used. If the oscillatory effect is to be observed it is necessary to include an amplifier in the circuit. A suitable form for the circuit to take is shown in Fig. 2, where the microphone M is connected in series with a battery B, a milliammeter A, a rheostat R, and the primary of the input transformer of a three-valve amplifier. The sound can, of course, be heard in the telephones, and provided that the grid lies in an approximately horizontal plane (*i.e.*, that the axis of the neck of the resonator is vertical) the pitch heard is the same as that of the original sound. It is therefore important in any experiment where comparisons of the strength of sound are being attempted, that the position of the microphone relatively to a horizontal plane should not be changed during the experiment. The difficulty can be overcome by arranging that the microphone shall always hang so that the axis of the neck is vertical. Small deviations of one or two degrees from this position do not materially affect the sensitivity.

This method of employing the microphone for the measurement of a sound, however, is not altogether satisfactory, on account of the difficulty of maintaining an amplifier in such a condition that the current amplification is constant for any length of time; and for this reason the Wheatstone's bridge method is sometimes preferable. The advantages of the amplifier method are that it is very sensitive (especially when a vibration galvanometer is used) and that the microphone can be placed in a moving piece of apparatus, subject only to the restriction that its axis must always be vertical (or at some fixed angle to the horizontal). Vibrations communicated through the mounting of the microphone (even when they are produced by striking the container) have very little effect on the sound heard in the telephones.

The Wheatstone's bridge method is preferable to the amplifier method on account of its greater simplicity, and because there is no danger of the sensitivity changing during the course of a long series of observations. A convenient form for the bridge to take is shown diagrammatically in Fig. 3. The microphone M with the milliammeter A forms one arm of the bridge. The balancing arm R is made about equal to the resistance of the grid when carrying its working current, *i.e.*, about 350 ohms. The rheostat Rh is inserted as shown in series with the battery, a balance being obtained by adjusting Rh until the current through the microphone brings its resistance, together with that of the milliammeter, up to R. For some purposes it is convenient to have a small variable resistance ρ in series with the microphone. In most experiments it is sufficient to take the deflection of the galvanometer as a measure of the intensity of the sound affecting the microphone; but other methods can, of course, be used.

A good illustration of the behaviour of the instrument may be given by observing the glowing grid of such a microphone when the sound reaches it. It has been found that the opening and closing of a door with sufficient suddenness gives a very fair imitation of a gun sound. The effect of this operation is to make the grid "blink" momentarily. At the same time a motion of the galvonometer spot across a screen, indicating change in electrical resistance, shows how sensitive this microphone is.

Mere noise, however, does not produce an appreciable effect, as can be shown by sounding a Klaxon horn in the immediate neighbourhood of the microphone.

The selective character of the microphone may further be illustrated by contrasting it with the solid-back carbon microphone. In July, 1916, the author was able to take parallel records of sound at Mount Kemmel with these two instruments. There were sounds of all descriptions—traffic, conversation, rustling of wind in trees, and distant

gun and rifle fire, but the hot wire microphone was found to ignore all but the low frequency gun-fire.

The microphone has an obvious application to such experiments as those recently conducted in Holland. The Meteorological Department of the Air Ministry asked the author to try and obtain records of the great explosion of October 28th, and special arrangements were made for that purpose. Attempts were made to secure records at Woolwich and Biggin Hill, and the results were shown during the lecture by means of lantern slides.

The records show, as would be expected, that the sound can arrive by a number of routes so far separated as to give separate concussions. The records of Biggin Hill are very interesting and appear to give evidence of transmission through the ground of a very marked character, but it is too early yet to report finally on conclusions.

Probably the one thing that impresses one most in connection with the instrument is its surprising sensitivity to low frequency disturbances—disturbances which produce no effect on the human ear, since they are below our range of audibility, and it is immediately obvious that such an instrument might be harnessed to apparatus for the measurement of vibrations in structures.

The microphone, as a measurer of impulses, is more difficult to explain than when used for the measurement of continuous sound. It was at first thought that the hot wire microphone could not be used for this purpose, but the remarkable magnifying powers produced by resonance enable one to get sufficient disturbance with sounds of one predominating frequency to affect the hot wire.

For accurate recording, resonance in the containing vessel should be discouraged by perforating its walls. If, however, these walls were left intact, it was found that the vessel with its microphone orifice had a very definite note of its own to which it would respond with great vigour. Excited by the sound of the same musical pitch, the resonator, as we may now call it, produces intense vibration in the neighbourhood of the hot wire and so cools it, and, moreover, cools it periodically. This resonator is no new discovery. It was described by Helmholtz, and its theory has received a complete treatment by the late Lord Rayleigh.* From known dimensions of the resonator, its magnifying power can be calculated, and it can be shown that resonance in a given case is confined to a very short range of frequencies, comprising about 6 per cent. of the mean frequency, so that it is only capable of responding to a range of a musical tone.

The overtones to which it can further respond are of such high pitch, and so relatively feeble, as to make it the most selective type of resonator known.

The microphone may be tuned by altering the volume of the resonator or by altering the dimensions of its neck—thus a larger volume or a longer neck would be employed for a lower note. In general, alteration of volume is the most satisfactory method of tuning.

One of the advantages of this type of microphone is its insensitivity to other disturbing noises as can be shown by substituting a galvanometer for the telephone so that the response of the microphone is shown visually. Here the magnified alternating current is first made unidirectional by means of a crystal rectifier. A Klaxon horn and other disturbances near produce no effect, but the slightest hum on the appropriate note is immediately detected.

Even tapping the microphone produces no appreciable effect, and the power to ignore shock makes it very useful for listening in places where the supports are subject to all kinds of accidental vibration. A carbon microphone, for instance, detects the slightest disturbance in its vicinity, and this is easily shown by tapping it and observing the effect on a vibration galvanometer. For this reason also, the hot wire microphone can be carried about a room, and will show by the galvanometer deflections the variation of intensity of sound at different points in the room.

Even in this form the microphone has not shown its maximum sensitivity. It can be demonstrated that if the microphone be mounted with its neck penetrating the wall of a cubical box, the side of which has a sliding door, a much better effect is obtained if the door be opened to a certain degree. The box itself becomes a resonator, and when tuned to the microphone note, the combination is extremely sensitive to the sound of correct pitch.

This phenomenon of double resonance in which the sound waves surge through the orifice between the two boxes has its analogy with the tuned wireless circuits in a wireless receiving installation. The combination exhibits not one, but two resonance peaks and gives a much wider range of tuning, while at the same time giving large magnification.

The best effect is produced by such careful tuning that two resonance peaks of equal magnitude are obtained. So far this instrument is the most sensitive detector of sounds it has been possible to produce and can easily beat the ear. Its high selectivity also enables it to hear in the midst of disturbing sounds. The greatest trouble that all microphones experience is disturbance due to wind. The hot wire microphone presents special difficulties, and much attention has been given to their solution. Mr. E. S. Player has, however, discovered a very efficient wind screening device, which embodies the use of ordinary "loofah." The effect of the fibrous structure is to break up any wind impulses without obstructing the passage of air or of sound. A microphone protected with such a loofah screen was exhibited.

We may now turn to some investigations to which the microphone has been satisfactorily applied. Its consistency of behaviour enables it to be employed for the accurate comparison of sounds of the same quality, for the ohmic change produced in the hot wire of the microphone is a direct measure of the intensity of the sound.

If the sounds to be compared are relatively feeble, a well tuned microphone would be employed, but if the sound is very intense, as in the neighbourhood of the Trinity House sirens, a microphone whose note is well below that of the siren is adopted. Thus, two fog horns were compared on the Channel Islands with a microphone of pitch 50 vibrations per second, that of the horns being 180 vibrations per second in each case.

If we use a source of sound of a given pitch, we can find out:—

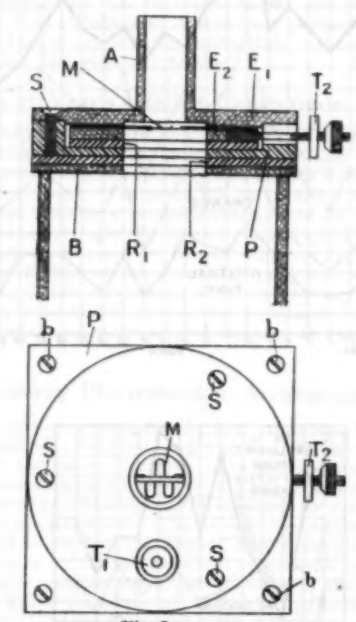
(1) How the transmission of such sound is affected by weather conditions.

(2) How the sound is distributed in certain enclosures, such as rooms of different sizes and shapes, and how that sound is modified by opening windows or doors or distribution of the audience, or the furniture in a room.

(3) How the sound is modified, magnified or distributed by the intervention in its path of trumpets, reflectors or obstacles.

The hot wire microphone has one distinct limitation—it is relatively insensitive to high pitch sounds—but with the development of more sensitive apparatus for the measurement of effects it will ultimately be available for this class of work also. Intensity of sound—as distinguished by the ear, will correspond to certain ohmic changes, which will be smaller and smaller as the pitch rises—but such ohmic changes, with the sensitive apparatus now at our disposal, should be easily measurable.

The work above described was carried out under the auspices of the Munitions Inventions Department, and the Signals Experimental Establishment. The author is greatly indebted to Capt. Paris and the staff of the Acoustical Research Section for their co-operation in this work.



"THE ENGINEER" Fig 1.

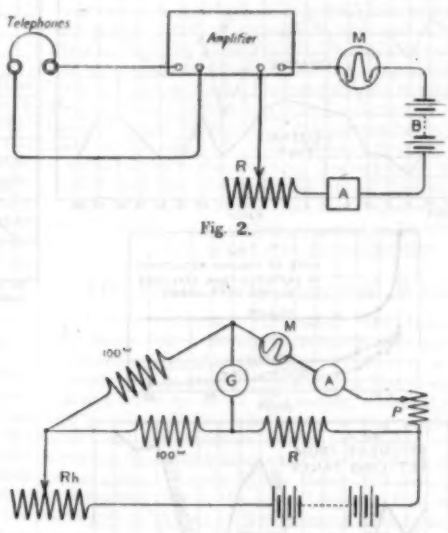


Fig. 2.

Fig. 3.

SWAN Sc.

CONSTRUCTIONAL DETAILS AND CONNECTIONS OF THE HOT WIRE MICROPHONE

* Rayleigh's "Theory of Sound," Vol. 2, Chap. XVI.

THE necessary capital has been subscribed in India, according to *Indian Engineering*, for the formation of a company to be known as the Peninsular Locomotive Company. The production of locomotives on an extensive scale is expected to begin shortly.

THE Air Ministry is about to vacate the Castle Bromwich aerodrome, near Birmingham, where the British Industries Fair has been held for the last three years. The sheds and sidings erected by the Government during the war have been purchased for £12,500, and it is understood that they will be leased by the Birmingham Tame and Rea Drainage Board to the British Industries Fair for five years at a rental of £1850 per annum, to include cost of painting and general maintenance.

Insurance by Industries.

WE give below the text of a Memorandum on Unemployment Insurance, issued last week by the Minister of Labour. The Memorandum has been prepared after a careful examination of views expressed by associations of employers and of employed, and is published by the Government with the object of extending the discussion and consideration of the subject.

1. In February last the Minister of Labour, following out a recommendation of the Geddes Committee that the possibility of extending unemployment insurance by industries should be further explored, addressed a letter to a large number of representative associations of employers and employed asking their views on this subject.

2. The replies to this letter have been carefully examined, together with certain other proposals and suggestions which have been put forward from various quarters. A large number of letters were sent out to the representative associations indicated above; the number of replies received has been frankly disappointing—about 10 per cent.

3. The Minister thinks it may be useful at this stage to direct attention by means of this Memorandum to certain methods of approaching the problem that might profitably receive consideration. It should be understood that the suggestions indicated in this Memorandum are intended only for the purpose of inviting discussion, and do not represent any conclusion reached by the Minister on the points raised.

4. It is desirable at the present time to consider the whole problem on the broadest lines, but it must not be forgotten that there is in the existing law a limited provision enabling an industry to undertake its own insurance. That provision—Sec. 18 of 1920 Act—has only so far been made use of by one industry, and is for the time being in suspense owing to the financial position of the Unemployment Insurance Fund; indeed, as the power of "contracting out" of the general State unemployment insurance scheme is restricted to "industries," formidable difficulties of demarcation arise, and the necessary measure of common agreement among the diversified interests which exist in almost any industry is difficult to secure.

5. In any development, the main objects to be kept in view are:—

(*a*) To link up together as closely as possible the financial responsibility for paying benefit with the responsibility of finding employment, so as to give the greatest possible incentive for the reduction of unemployment.

(*b*) To give a full opportunity to industries (or smaller units) of providing for their own unemployment in the hope that, at any rate in the case of industries with average or less than average risks, it will be possible to secure (without any diminution of reasonable contributions from the State) additional advantages for the worker.

Possible methods of securing these objects are indicated in the paragraphs below.

METHOD A.

6. It is for consideration whether the responsibility for unemployment and unemployment insurance should be deflected entirely away from the State and placed upon industry. The steps that necessarily have been taken in the past four years have fostered the view that the responsibility is a State matter. It may be contended that this is not a right view, and that the duty of making provision for unemployment should be placed more directly on those engaged in industry. On this basis unemployment insurance would take some such form as follows:—

As from an appointed date, a statutory liability would be placed upon every employer to devise in association with his workpeople an approved scheme of unemployment insurance. By such scheme any workmen in the employment of the employer on or after the appointed date would, if and when the workmen became unemployed, receive from the employer (or from such joint agency as the employer and his workpeople might have set up) unemployment benefit at the prescribed rate for a prescribed period.

It is not necessary at this stage to elaborate the details of this proposal; but provisions would probably be required enabling employers to deduct agreed contributions from the workers' wages; and arrangements would be necessary for workers not in employment at the appointed date to remain under the State insurance scheme, at any rate for a time.

METHOD B.

7. Bearing in mind (1) the extent to which there is movement of labour—particularly unskilled labour—from one industry or establishment to another; (2) the fact that in almost every trade there is a "margin" or fringe of labour exposed to more than the normal risk of unemployment; and (3) the fact that there are very large numbers of small employers whose circumstances are such that they could not readily set up a self-contained private scheme, it may be found that there is much to be said for continuing the State unemployment insurance scheme in its entirety, but at the same time making arrangements whereby industries having private schemes of insurance would contribute to the State insurance fund only an appropriate part of the contribution in order to cover the cost of what might be termed a "basic rate" of benefit, the balance of the contribution being retained by the industry for the purpose of providing other benefits suited to its own conditions.

Under such an arrangement all insured workers in whatever industry, and however they moved from one industry to another, would be secured at least the advantages of the State scheme; but it is clear that only industries with relatively low risks would initiate private schemes.

METHOD C.

8. Another suggestion, intermediate in character between Method A and Method B, would be along the following lines:—

(i.) There should be every encouragement to employers and workpeople to devise arrangements which, with

proper safeguards, would amount in each case to a self-contained scheme for the industry or part of the industry (including, of course, all classes of labour employed), those who are out of employment receiving their unemployment benefit from what may be termed a "private scheme."

(ii.) Private schemes for industries with high risks, as well as for industries with low risks, should, if possible, be facilitated by means of an adjustment—under adequate safeguards—of the contribution from the State insurance fund, such contribution being higher in the case of industries with high risks than in the case of industries with low risks.

(iii.) So far as employers and workpeople are not covered by private schemes, they must be dealt with by the State scheme.

(iv.) In accordance with the general principle of insurance, industries or parts of industries where unemployment is low must contribute to some extent towards the provision to be made under the State scheme for industries where unemployment is high.

(v.) In order to limit the liability of employers and workpeople and at the same time to secure to the workpeople the payment of unemployment benefit for a reasonable period, those insured under a private scheme might be a charge upon that scheme for some specified period, falling back upon the State scheme when that period has been exhausted.

(vi.) Industries or parts of industries which undertook to devise and maintain private schemes might contribute to the State fund only such amounts as might be ascertained to be the appropriate charge upon that industry or part of the industry in respect of (*a*) its proportion of the general burden of unemployment in the country, and (*b*) the estimated cost of the fall-back benefits payable from the State insurance fund to workpeople in whose cases the payments under the private scheme had come to an end.

(vii.) Industries or parts of industries that did not devise and maintain private schemes would have to pay the full contribution to the State insurance fund.

9. The administrative problem is to determine in relation to each of these alternatives the way in which private schemes may be encouraged, whilst at the same time securing:—

(*a*) That there is a definite incentive to industries to devise means whereby the volume of unemployment is kept as low as possible;

(*b*) That workers moving from one industry to another remain effectively covered by insurance;

(*c*) That the cost of unemployment insurance to the Exchequer is not increased beyond that normally involved by the present Unemployment Insurance Acts;

(*d*) That the arrangements are sufficiently simple not to lead to excessive expenditure upon administration, whether by the Government Departments concerned or by those responsible for the private schemes.

Indian Engineering Notes.

(*From our own Correspondent.*)

BOMBAY, November 11th.

The Khyber Pass Railway.

A COLLEAGUE who has recently toured the North-West Frontier tells me that excellent progress is being made on the construction of the railway through the Khyber Pass. The railway is an extension of the North-Western Railway of India from its terminal station at Jamrud, some 3 miles from the entrance to the Pass, to Landi Khana on the Afghan frontier. In its inception the railway was mainly strategical, but the rather remarkable awakening of Afghanistan during the past few months has created the impression that the completion of the railway will result in an unprecedented exchange of trade between India and that country, a trade which has hitherto been carried on upon a comparatively limited scale by means of caravans of camels. Some idea of the ruggedness of the country through which the railway passes may be gleaned by the statement that in the course of the twenty-seven miles which comprise its length, there are no fewer than twenty-seven tunnels and three reversing stations. Altogether there will be eleven stations, each of which will be provided with a defensible *sarai* for the protection of the line against tribal raiders.

Harnessing the Sutlej.

Professional agitators in India are untiring in their efforts to hamper industrial progress. Their activities have been particularly noticeable in connection with hydro-electric projects, many of which, it is claimed, bear harshly upon agriculturists whose lands are in the vicinity of the affected area. This opposition has been neatly countered in what is officially known as the Sutlej River hydro-electric project, for here the waters of the river will be short-circuited in such a manner that a fall of 340ft. will be made available for the generation of electric current, and the whole of the water will then be returned to the river. This scheme is made possible by the wide, sweeping bend of the Sutlej which occurs at Malauna, and it involves the boring of a tunnel 20ft. in diameter and 10,000ft. in length, and the construction of a surge chamber at a depth of 200ft.

Howrah Bridge.

There has been an interesting development in connection with the proposed reconstruction, or rebuilding, of the famous bridge across the river Hugli in Calcutta. It will be recalled that the report of the Committee appointed by Government was forwarded to London for further consideration by the High Commissioner for India and his experts. Now comes news that a Calcutta firm of engineers has submitted another design which is said to be a modification of the twin floating bridge suggested by Sir Bradford Leslie, and will actually mean only the reconstruction of the existing bridge so as to afford a much wider roadway for traffic and also to permit of the passage of trains. The cost, it is claimed, will be considerably lower than would be the case in connection with any of the plans previously submitted. It is significant that the Committee is said to be "keeping an open mind" on the subject, despite the fact that its report was handed to Government some months ago.

Kolar Goldfields.

There have recently been several instances in the Kolar goldfields of activities tending towards an increased output of the precious metal; but of even greater importance are the means which are being adopted to eliminate waste. In the latter respect, considerable interest attaches to the new magnetic separator and machine blanket plant which was put into operation for the first time a few days ago, and is said to be the first of its type in the world. During the process of stamping the quartz to a fine state of division, a quantity of metallic iron is eroded from the stamp shoes and dies, and from the liners of the tube mills. This iron becomes mixed with the crushed quartz and causes trouble during the subsequent chemical processes; but by the use of the new machinery—which has been installed at the Ooregum Mine—the iron is extracted from the pulp by magnetic separation. The other portion of the plant, the blanket machine concentrators, have as their object the recovery of any gold which has become coated or dirty, and which may have escaped extraction in the previous amalgamation process. The whole installation is entirely automatic, and can be tended by one man.

News in Brief.

Three 300-ton steel oil tankers are being built at the Colombo works of Messrs. Hoare and Co., and of these the first has just been launched. Although small, they are interesting as being the largest steel vessels yet built in Ceylon.

The Andhra Valley Power Supply Company, the second of the series of four huge hydro-electric installations which the firm of Tatas is erecting in Bombay Presidency, has just commenced supplying current to Bombay. Current is generated at 5000 volts, and after being stepped up to 100,000 volts, is transmitted to Bombay, a distance of 56 miles, through overhead bare wire cables.

Messrs. Rendle, Palmer and Tritton, of Westminster, have been appointed consulting engineers to the Bombay Municipality in connection with the erection of a bridge which will carry the pipe lines which are being installed with a view to doubling the city's water supply.

The discovery of new coalfields at Talcher is likely to result in the formation of a new industrial centre in and around Orissa. An ambitious project is already afoot for the erection of a paper mill, for which the supplies of raw material will be bamboos floated down the Mahanadi River.

Agricultural Implements, Limited, will commence operations during December. Automatic machinery has been installed in the company's new factory at Jamshedpur, close to the Tata Iron and Steel Works. The tin-plate company at Jamshedpur is expected to make a start in January.

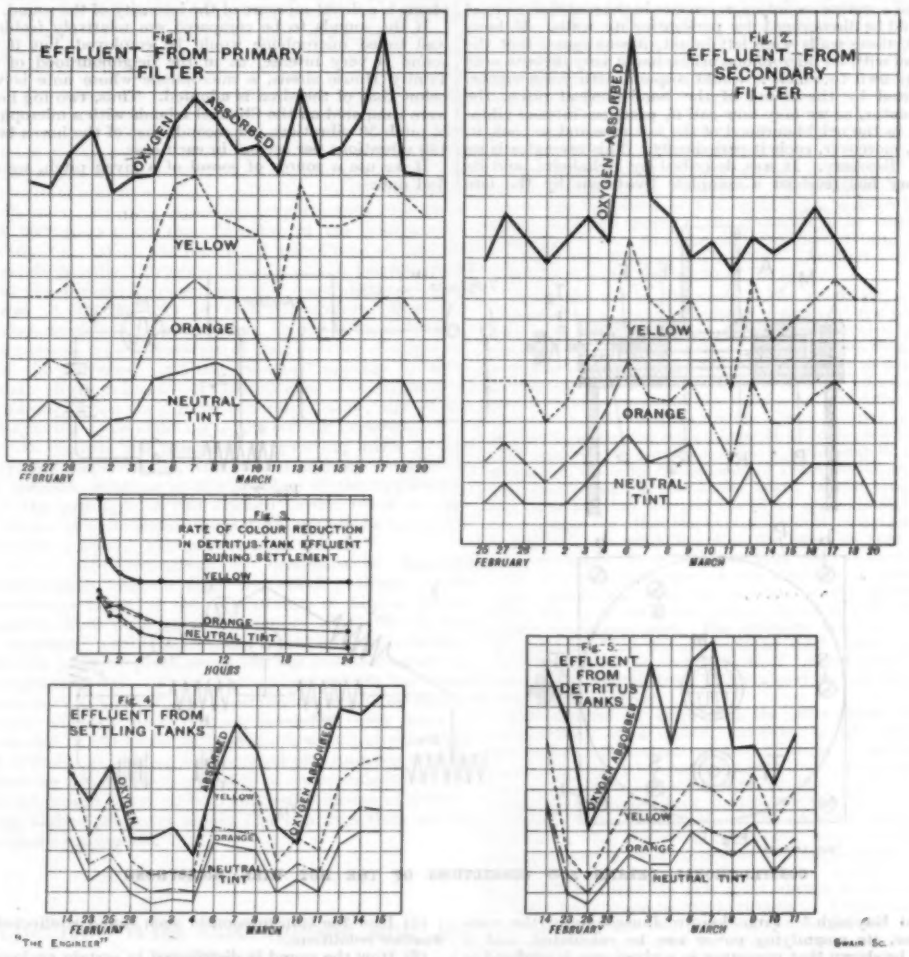
A Colorimetric Method of Analysis for Sewage Effluents.

By R. C. S. WALTERS, B.Sc., Assoc. M. Inst. C.E., and V. G. PICKERING.

THE accompanying curves are the results of some experiments carried out in order to find out a relationship, if any, between the density of colour in, and the amount of oxygen absorbed by, sewage effluents from the sewage works of the Corporation of Cheltenham.

It is fairly well established that with *potable* waters the amount of neutral tint, as seen through a colorimeter or tintometer, is directly proportional to the amount of oxygen absorbed.* This relationship will be seen to be applicable to sewage effluents after single—Fig. 1—and after double filtration—Fig. 2—and under certain conditions even to settling tanks effluents—Figs. 4 and 5.

The oxygen absorbed tests were carried out by the acid-permanganate method after three hours' digestion, and the corresponding colour values were measured through a 9in. trough of the Lovibond tintometer. This instrument contains fifty yellow, blue and red glasses of different shades, which are inserted to match any desired shade of liquid in the trough; the yellow, blue and red together making the neutral tint, the remaining yellow and red forming orange, with a certain amount of yellow left over in every case.†



RELATIONSHIP BETWEEN DENSITY OF COLOUR IN, AND OXYGEN ABSORBED BY SEWAGE EFFLUENTS

Figs. 1 and 2 show a remarkable agreement between the oxygen absorbed and the colour tests, and as the latter occupies less than five minutes to perform, while the former takes three hours or more, it is thought that such a simple piece of apparatus as the tintometer might be more in general use in sewage works, not necessarily to supersede the work of the chemist, but to be used by the sewage works manager and those visiting inspectors and engineers, with limited time, who would like a simple test as an adjunct to the customary shake and smell test.

A few experiments carried out on the detritus and settling tank effluents, which are of more academic than practical interest, show that the tintometer is not so well suited, owing to the turbidity of the sewage, which takes periods of tweny-four hours or more to settle in the trough. Fig. 3 gives to the eye the law of settlement of such effluents, showing a rapid settlement followed by a slower settlement. Figs. 4 and 5 compares a few oxygen absorbed tests with colour tests on the detritus and settling tank effluents; the colour readings, being taken after different periods of settlement, are reduced in accordance with the curve of Fig. 3 to equivalent values taken six hours and half an hour after settlement, respectively.

In all these tests, the colour and amount of oxygen absorbed appeared to have no connection with (i) the quantity of sewage per twenty-four hours, (ii) the flow through the filter when the sample was taken, and (iii) the number of revolutions of the distributor per day.

The density of the neutral tint is said to vary with the number of bacteria in the water, but further research is necessary to establish this statement definitely.

* "Transactions," Inst. Water Engineers, Vol. XXII., p. 32.

† A full description of this instrument is given in "Transactions," Inst. Water Engineers, Vol. XXII., p. 19.

A Seven-Day Journal.

The New Battleships.

TOWARDS the end of last month the First Lord of the Admiralty, speaking in Parliament, intimated that some of the tenders for the two new battleships, their armament and armour had already been received and considered, and that he hoped a decision in the matter would be reached very shortly. A fortnight before Mr. Amery made this announcement, we called attention in the Journal to the fact that under the Washington Agreement there was a limit to the time within which the ships permitted by that Agreement may be constructed, the object of this limitation being to prevent one nation stealing a march upon another by delaying construction with the object of taking advantage of the latest technical developments. Within the past few days, as the Prime Minister announced on Monday, the Government has learnt from its legal advisers, apparently much to its surprise, that unless the ships are laid down by the last day of this year Great Britain's right to construct them will have lapsed. Moreover, if the opportunity is foregone, this country will, under the terms of the treaty, be denied the right to increase the number of its capital ships until November 12th, 1931. As all our vessels of the battleship class, with the exception of the Hood, are of pre-war design, it is obvious that the situation which has arisen by the procrastination shown in placing the contracts for the new vessels is one of great urgency. All things considered, it is thus likely that construction will be begun before this month expires. The Government has at least pledged itself to come to a decision in the matter before the end of the present parliamentary session.

Next Year's Gliding Competition.

PARTICULARS are now available of the conditions under which next year's gliding competition for a prize of 1000 guineas, offered by Mr. Gordon Selfridge, will be regulated. The prize will be awarded to the competitor who first covers a distance of 50 miles, measured in a straight line, in one uninterrupted flight. The competitors must be British subjects, and may start their flight from any point and at any time within the year. If the chief prize is not won by any competitor, a prize of 500 guineas will be awarded to the entrant who covers the longest distance in excess of 25 miles.

A Railway Electrification Arrangement.

IT is intimated that Sir W. G. Armstrong, Whitworth and Co., Limited, and the British Thomson-Houston Company, Limited, have entered into an arrangement under which they will act jointly in the provision of equipment and rolling stock for railways adopting electrification. The locomotives and rolling stock will be produced at Messrs. Armstrong's Scotswood Works, while the electrical equipment for the locomotives, rolling stock, power stations and sub-stations will be manufactured at Rugby by the British Thomson-Houston Company. The Vickers group, including the former British Westinghouse Company and the Metropolitan Railway Carriage and Wagon Company, is already deeply interested in railway electrification. Last April, it will be recalled, the Power and Transport Finance Company was formed by, among others, the English Electric Company and the North British Locomotive Company, with railway electrification work as one of its main objects. The arrangement now announced is no doubt an outcome of the formation in October of the Power Securities Corporation. This body has for its announced object the assistance, financially or otherwise, of the development of engineering and electrical undertakings, and was formed by the joint action of Babcock and Wilcox, the British Thomson-Houston Company, Armstrong-Whitworth, and Balfour, Beatty and Co. There are thus three strong groups in existence in this country interested in the electrical equipment of railways.

Unemployment Insurance by Industries.

WHILE the Government is taking more or less emergency steps to meet the present situation with regard to unemployment, it is not neglecting to look ahead with a view to providing against a recurrence of severe unemployment in the future. To this end, the Ministry of Labour is endeavouring to secure opinions on the proposal that each industry or section of an industry should be responsible for its own unemployment The Ministry has addressed a letter to the National Confederation of Employers' Organisations and to the General Council of the Trades Unions Congress, and has asked these two bodies to co-operate with it in investigating the advantages and possibilities of insurance by industry, as suggested by the Committee on National Expenditure a year ago. The letter indicates three possible alternative methods of carrying out the scheme, but for particulars of these methods we may refer the reader to the letter itself as reprinted elsewhere in this issue. It may here be noted that in December, 1921, it was not thought likely that the appointment of a committee to investigate the matter, as suggested by Sir Eric Geddes and his fellow-committeemen, would serve the object in view. Nevertheless, with a view to preparing the ground, Dr. Macnamara, the late Minister of Labour, took steps to obtain the views on the matter of a large number of representative associations of employers and employed. A committee of the Department was appointed to examine the replies thus received and suggestions which came from other sources, and as a result certain broad indications as to the principles on which the scheme might be carried out have been collected and embodied in a memorandum which has now been submitted to the consideration of the Confederation and General Council. The Minister, in his covering letter, makes it clear that he retains an open mind on the subject, and points out that not only are there many difficulties in the way of carrying out the scheme, but that there are various alternative lines of development which will have to be explored.

The British Empire Exhibition.

A FORTNIGHT ago we made reference to the threatening situation which had arisen by reason of the criticism directed against the Executive Council of the British Empire Exhibition for its alleged failure to enforce preference wherever possible for Empire products in the construction of the buildings, the supply of food and refreshments, and so on. At a meeting of the Executive Council last Friday, it was stated that while the Council was satisfied that the criticism was without foundation, the special committee appointed to consult on the matter with the President of the Board of Trade had consented to a full investigation being made into the situation by Sir W. Joynson-Hicks, Director of the Overseas Trade Department, in order that the Government and Parliament might be placed in full possession of the true facts of the case. It is understood that the inquiry is to be begun without delay. Its outcome, it is to be hoped, will be the removal of all feeling in the Dominions and Colonies that the Imperial aspect of the Exhibition is in certain respects to be ignored for the sake of some minor possible advantages.

The Wolfe Barry Memorial Window.

AT noon yesterday—Thursday—the dedication of the Wolfe Barry Memorial Window was carried out in Westminster Abbey. The window is a notable addition to the stained glass in the Nave, and forms one of a series by Mr. J. N. Cowper, which, it is hoped, will in time fill the whole row of the windows. In each case the windows are in two lights, one filled with the figure of a king and the other with the figure of an abbot. In the Wolfe Barry Window, the king is Edward I., while the second figure is that of Walter of Wenlock, Abbot of Westminster in that sovereign's reign. Direct association with Sir John Wolfe Barry is provided by the reproduction of his coat of arms, surrounded by the chain of the Order of the Bath.

A Broken Engine Axle.

As the 10.20 a.m. express from Euston to Liverpool was travelling between Wolverton and Castlethorpe stations on Monday morning, the driving axle of the engine broke, causing the right-hand driving wheel to become detached from the engine, the right-hand intermediate coupled wheel to shed its tire, and the coupling and connecting-rods to be buckled. Although during the last twenty years only two accidents arising from broken engine axles have been inquired into, such failures are not as rare as may be supposed. They have to be reported to the Ministry of Transport, and on reference to the annual Accident Returns we find that for the seven years 1909–1915 inclusive the number of failures of crank and driving axles averaged 41.43 per annum. They were not returned during 1916, 1917 and 1918, and for the three years 1919–1921 inclusive the average was 37. For the whole of the ten years the total was 401, or practically 40 a year. In the accident on Monday the leading brake van was damaged and had to be detached, but no passenger complained of injury, and all proceeded on their journey to Liverpool.

Electric v. Geared Propulsion for Ships.

AT a recent meeting of a newly formed association of Liverpool marine superintendents and consulting engineers—an association at the meetings of which the keynote is informality—the question of electric *versus* geared propulsion for ships was debated in an interesting and instructive manner. It was, in general, agreed that for warships the great flexibility of control which could be secured by an electrical drive was of extreme value, but that for merchant ships, which run at or near their full speed for the best part of every voyage, the electrical drive lost something of its advantages. It was agreed, too, that for moderate powers, say, from 3000 to 4000 shaft horse-power, a geared turbine drive was preferable to electrical propulsion, although it was realised that the absence of a direct mechanical connection between the propellers and the power plant in an electrically driven ship and the silence of electrical machinery when running were strong factors in favour of the electrical system. It was urged that it was as yet too early to form a hard-and-fast opinion on the relative merits of the two forms of drive, for the next few years were bound to see considerable developments in each direction, and that each system might be found suitable in its own sphere. The internal combustion engine was not overlooked in the discussion, and marine engineer apprentices were strongly advised to study not only steam engines and turbines, but electricity and internal combustion engines as well.

Breaking Up Warships.

CRITICISM having recently been directed against what has been described as the Admiralty's "policy of sending ships to be broken up in Germany," the First Lord has found an opportunity in a reply to a correspondent to make it quite clear that the official policy is far otherwise. The number of ships to be broken up in accordance with the dictates of economy or with the requirements of the Washington Agreement has been so large that the shipbreaking firms in this country have been swamped with work. In addition, the low price obtained for scrap metal during the past few years has reduced the profits of the shipbreaking firms to a point at which it has become very difficult indeed for them to take on fresh work. In general, however, the Admiralty has disposed of its surplus ships solely to British firms, and has given perference to those which would undertake to employ ex-Service men on the work. By so doing, it has sacrificed the advantage to be gained by selling the vessels to foreign firms at higher prices on the average than could be obtained from British shipbreakers, and has incurred some loss by keeping the ships at valuable berthings longer than need have been the case. In one or two instances, however, it has permitted shipbreakers to re-sell ship hulls after the more valuable parts had been removed to foreign shipbreakers. By permitting this departure from the strict letter of the contract, the Admiralty has clear evidence that with the money received from abroad and the freeing of berthing accommodation at the shipbreaking establishments, British firms have been enabled to take on additional shipbreaking work, and so to give fresh employment to their workpeople. In one instance by allowing the re-sale of certain ships to foreign firms, a Plymouth establishment which otherwise would have had to have gone into liquidation, was enabled to continue the breaking up of fourteen other vessels comprised in its contract.

The Origin of the Parsons Turbine.

ON Tuesday, Sir Charles Parsons delivered a lecture on "The Rise of Motive Power and the Work of Joule" to the Manchester Literary and Philosophical Society, an institution of which Joule, along with Dalton, was a member. Sir Charles, after referring to the work of Joule, Carnot, Watt and Thomson in connection with thermo-dynamics, described how he commenced his own work on the steam turbine. To test the possibilities of the Hero turbine, he constructed one about thirty years ago with divergent nozzles, and found that with steam at 100 lb. and the jets revolving at 800ft. per second and with a good vacuum, it gave about the same efficiency as a good single reciprocating engine. This type of turbine did not, however, lend itself to refinement as readily as Bianca's turbine, which had lain dormant until 1883, when Dr. de Laval began to develop it, and, adopting the divergent nozzle in 1887, obtained an efficiency equal to that of an ordinary piston engine. In commencing his own work on the steam turbine, it appeared that as the laws for the flow of steam through orifices under small differences of head were known to correspond closely with those for the flow of water, and that as the efficiency of water turbines was known to be from 70 to 80 per cent., he considered that the safe course was to adopt a water turbine as a basis for the design of a turbine to use steam. It soon became evident that the mechanical difficulties which had been partially solved in the case of small turbines could be more completely solved in larger sizes. In short, it seemed probable that a large turbine could be constructed to expand the steam continuously from boiler pressure down to the lowest vapour pressure obtainable in the condenser with an overall efficiency within 70 to 80 per cent. of a perfect engine working under similar steam conditions. This supposition had ultimately been found to be true in large compound turbines. Thus in certain modern 10,000-kilowatt turbo-alternators, with steam at 250 lb. pressure superheated to 700 deg. Fah. and exhausting into a vacuum of 29in., the steam was expanded to one-five-hundredth of its original pressure, and one-quarter of the heat in the steam was converted into electrical energy.

The Smithfield Club Show.

No. I.

The Cattle Show of the Smithfield Club, which opened at the Royal Agricultural Hall on Monday, the 4th, and closes to-day, Friday, is said to make a record from the point of view of the stock breeder and, as looked at by engineers, it is also exceptionally interesting. For some time past the mechanical exhibits have had a very stereotyped character, and interest in the Show has flagged on account of the sameness in the machines shown from year to year. This winter, however, there are several novelties, and although it cannot, of course, be expected that they represent any very radical departure from previous practice, they indicate a progressive policy on the part of our manufacturers. It is noteworthy that steam engines still hold their ground for the really heavy work of the agriculturist and haulage contractor but in the opinion of some of the exhibitors, the lower first cost of oil engine tractors will before long seal the doom of the lighter steam tractors. In fact, one manufacturer went so far as to say that the best thing to do with existing stocks of these engines was to convert them into road rollers, when they found a ready market. Petrol and oil engines have, of course, been fully established as prime movers for small power purposes, and a great variety of them is exhibited at the Show. We begin below to give a description of some of the more novel exhibits.

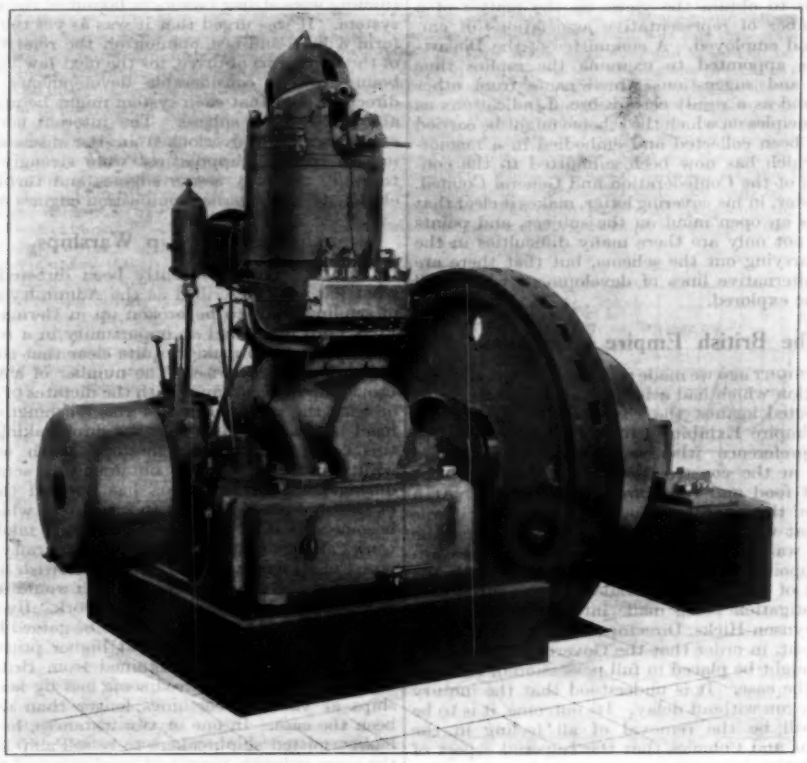


FIG. 1—MARSHALL 30-H.P. OIL ENGINE

Marshall, Sons and Co., Limited, Gainsborough, are showing a traction engine of standard type, a thrashing machine and several oil engines, one of which we illustrate in Fig. 1. This engine is of the hot-bulb, two-stroke type, described in The Engineer, November 18th, 1921, but the fuel pump is now arranged alongside the crank shaft instead of on a bracket off the cylinder. The new scheme is much more compact and ensures a more positive drive for the pump, as it is directly opposite, and close to, the excentric. The excentric has two sheaves, which are adjusted in relation to one another by the governor, fixed on the end of the shaft, so that the length of pump stroke and the time when the fuel is injected into the cylinder are varied to suit the load on the engine. The makers claim that these engines will run on a trifle over half a pint of practically any crude oil per brake horse-power per hour. The other engines on the stand are 8 and 12 horse-power sets of the horizontal engine, also described in our issue of November 18th, 1921, and a 16 horse-power unit mounted on a trolley together with its cooling tank.

Petters, Limited, Yeovil, are exhibiting a number of oil engines, two of which are shown in Figs. 2 and 3. They range, in output, upwards from a little hopper cooled set of 1½ brake horse-power, and include one of the smallest engines for running on heavy crude oil which we have seen. This type is made in several sizes, the least of which is of 5 brake horse-power, and is arranged vertically. At starting the ignition chamber requires heating for about two minutes, which is effected by an improved type of lamp. No external heat is required after starting, and the engine works well at all loads or even without any load at all. The speed, which is 600 revolutions per minute, is controlled by an efficient governor, while the fuel consumption is said to work out at a cost of about ¾d. per electrical unit, when the engine is used to drive a dynamo. The pumping outfit—shown in Fig. 3—is the standard model, known as the No. 3 size, with a 3 brake horse-power Petter Junior engine, and a double acting brass-lined pump, with a gun-metal piston-rod and machine-cut gearing. It is capable of delivering 1000 gals. of water per hour at a total head of 150ft. and vertical suction depth of 25ft. The electric lighting set, shown in Fig. 2, comprises a 3 brake horse-power engine connected by an endless belt with a dynamo giving 1000 watts at 37 volts. The switchboard is mounted directly on top of the dynamo, but can be fixed on an adjacent wall if so desired. The control is of a semi-automatic nature. These sets are supplied complete with a storage battery of 14 cells having a capacity of 125 ampère hours, and are made in several other sizes.

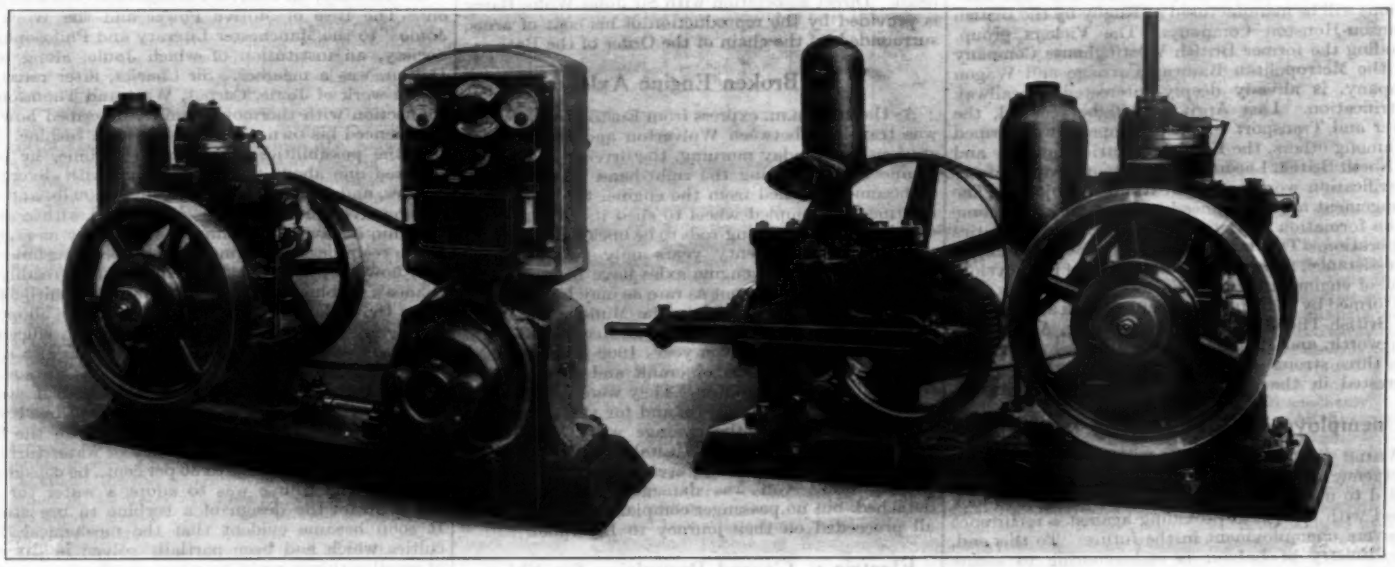


FIG. 2—PETTER 3-H.P. LIGHTING SET

FIG. 3—PETTER 3-H.P. PUMPING SET

William Foster and Co., Limited, Lincoln, are showing a 5-ton compound Wellington steam tractor, represented by Fig. 4, and a 5-ton steam wagon of the general type, illustrated by Fig. 6, but with a fixed body in the place of the tipping type shown in the picture. The tractor, it will be seen, is mounted on rubber tired wheels. It has a continuous economical output of 14 horse-power, but can work, in emergency, up to 22 horse-power. The engine, which has cylinders 4¼in. and 6¾in. in diameter, runs at 250 revolutions per minute, and by means of two sets of gearing, gives speeds of 3 and 6 miles per hour. The weight in working order is 6 tons, and the tractor will haul a gross load of 8 tons over good roads having gradients not greater than 1 in 20 when in the fast gear. With the low gear in use it will climb slopes as great as 1 in 8 with the same load. One of the noteworthy features about this engine is the springing system, in which the springs of the back axle are arranged outside the horn plates and above the axle, so as to minimise swaying as far as is possible. The boiler is worked at a pressure of 210 lb. per square inch, and the water tanks have sufficient capacity for running 18 miles. The steam wagon is nominally of 5 tons capacity, but it will also haul a further load of 3 tons on a trailer, when the speed is reduced from 8 to 5 miles per hour. The engine has cylinders 4in. and 6¾in. in diameter by 7in. stroke, and takes steam at a pressure of 200 lb. per square inch. There is a change-over valve by means of which high-pressure steam can be admitted to the low-pressure cylinder for overcoming a temporary overload. The boiler, which is tested with a hydraulic pressure of 350 lb. per square inch, has a heating surface of 75 square feet and just over 2½ square feet of grate area. By means of a double pinion mounted on a squared extension of the crank shaft, two speeds, of 4 and 8 miles per hour, are provided for, the change being worked by one lever from the footplate. The drive is taken from the pinions on the crank shaft to large intermediate wheels; and is then taken by a roller chain to the differential gear on the main axle. The differential gear may be locked for travelling over loose or soft ground. The gearing is of cast steel, machine-cut throughout. The front wheels are fitted with single rubber tires 2ft. 9½in. in diameter, while the rear wheels have twin rubber tires 3ft. 5½in. outside diameter. These wheels are interchangeable and are easily removable, as they are bolted to taper sleeves on the rear axle.

Aveling and Porter, Limited, Rochester, have three engines, of which the most interesting is the 7 nominal horse-power traction engine, illustrated by Fig. 5. The most novel features about this engine are the Belpaire fire-box, piston valve, and the steel pressing

used as a seating for the cylinder. The piston valve has been adopted on account of an increase in the steam pressure, to 140 lb. per square inch, and has resulted, we were told, in a saving of some 8 horse-power in the output of the engine. The excellent steam distribution obtained with this valve is disclosed by the indicator diagrams, which we reproduce in Fig. 7, and which were taken off the engine just before it was dispatched for exhibition. The valve is so arranged as to take steam on the outside and exhaust at each end and through the hollow portion of the valve to the exhaust pipe. It is of ample capacity to allow a free and ready exhaust, reducing the back pressure on the piston to a minimum. The cylinder is mounted on a pressed steel base, riveted and stayed to the boiler, the base and the foot of the cylinder being machined to ensure an accurately fitting joint. A governor, of the Pickering type, is fitted. The piston has Ramsbottom rings, and a hammered steel piston-rod. The connecting-rod, crank shaft and intermediate shafts are of steel with heavy gun-metal bearings. The driving axle is of special quality oil toughened steel, carried in cast steel axle-boxes with gun-metal bearings. The turntable is of cast steel, while the top casting is enclosed at the top forming an oil chamber above the shank of the bottom casting, lubricated by a Stauffer grease cup. The gearing throughout is of cast steel, and is arranged for two speeds. The first and second motion gears are machine cut, and all double wheels are cast separately and bolted together. The tender of the engine is unusually substantial, and is built throughout of ¼in. steel plate, hydraulically flanged; the side plates considerably overlap the boiler horn plates, and are bolted thereto. The drawbar is fitted to the back of the tender, with side bars extending on each side and terminating in a ring around the bosses of the axle-boxes. The pull is thus entirely transmitted to the main structure of the engine. Inside the smoke-box there is a loose lining which can easily be replaced if it becomes burnt. The leading dimensions are as follows:—Cylinder, 8½in. diameter, 12in. stroke; crank shaft, 3¼in. diameter; driving road wheels, 6ft. diameter; front road wheels, 4ft. 6in. diameter, 8in. wide; fly-wheel, 4ft. 6in. diameter, 5½in. wide; heating surface, 119 square feet; grate area, 5.58 square feet; tank capacity, 144 gals.; brake horse-power, normal, 27, maximum, 45; tested pressure, 350 lb. per square inch; working pressure, 140 lb. per square inch.

Ransomes, Sims and Jefferies, Limited, Ipswich, have their familiar balconied stand, with a traction engine, thrashing machine and several agricultural implements, together with a 3½ brake horse-power Wizard vertical oil engine. The peculiar feature about this engine is the arrangement used for atomising the fuel. The oil tank is kept under a moderate pressure by a non-return connection with the crank case—it is a two-stroke engine—and the fuel is thus forced into a chamber above the cylinder head. A valve in the bottom of this chamber is opened by a tappet rod just at about the end of the compression stroke, and admits a charge of fuel into a little cup below. This cup projects into the combustion space, and is closed except for three minute holes, through which the fuel is projected into the cylinder by a minor explosion that takes place inside the cup, and is provided for by air supplied through the holes during the compression stroke. The result is that the fuel is atomised very thoroughly, and the main explosion in the cylinder is assured regardless of the load on the engine. A few small steel balls are left loose to rattle about in the cup and keep the holes clear of incrustation. Lubrication is effected by means of a force pump, which receives its supplies from a sight feed, while the spent oil is constantly expelled from the crank case by the compression pressure. We were told, at the exhibition, that one of these little engines was recently put to work driving the fan of a hop drying installation, and that it had run for a fortnight continuously without any attention beyond that necessary for replenishing the fuel and oil tanks.

Richard Garrett and Sons, Limited, Leiston, have a steam wagon of the type which we described and illustrated in THE ENGINEER of April 7th, 1922, but which is equipped with the new style of boiler we then forecasted. It is of the vertical type with cross water tubes pointing fore and aft, and lying at a slight angle. In front of the bunch of tubes there is a large door held in place by stud bolts and strengthened within itself by a deep dishing. Through this door the whole of the tubes can be scaled, and the *débris* washed down into the bottom of the boiler; whence it can be swilled out through the mud holes. The distance between the outer shell and the fire-box is sufficient for a man to get his arm in and clean out the space. Firing is effected through an opening in the side of the boiler beneath the footplate, which is provided with an upwardly extending shoot, so that the man has merely to dump the coal in the shoot and put the lid on again. There is another fire-door in the front of the boiler, accessible from the road, through which the fire can be lighted and cleaned. A zigzag coil of pipe is arranged in the top of the fire-box for superheating the steam. With the exception of this new boiler, the wagon is similar to that which we have already described.

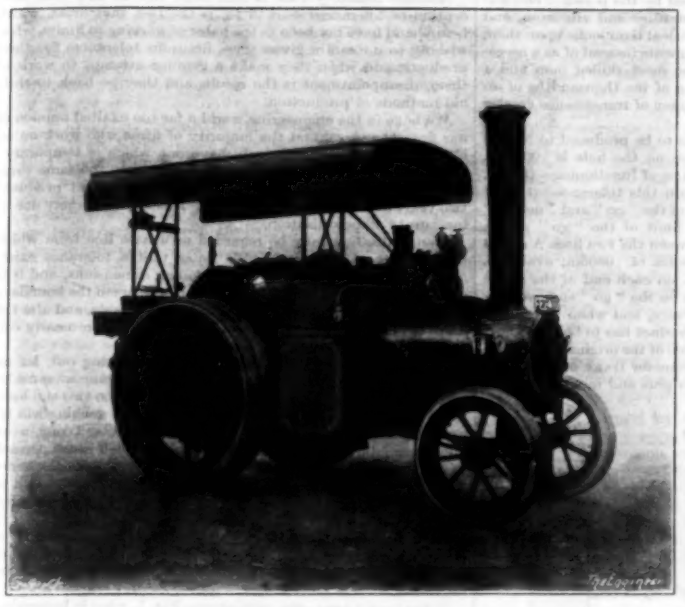


FIG. 4—FOSTER "WELLINGTON" TRACTOR

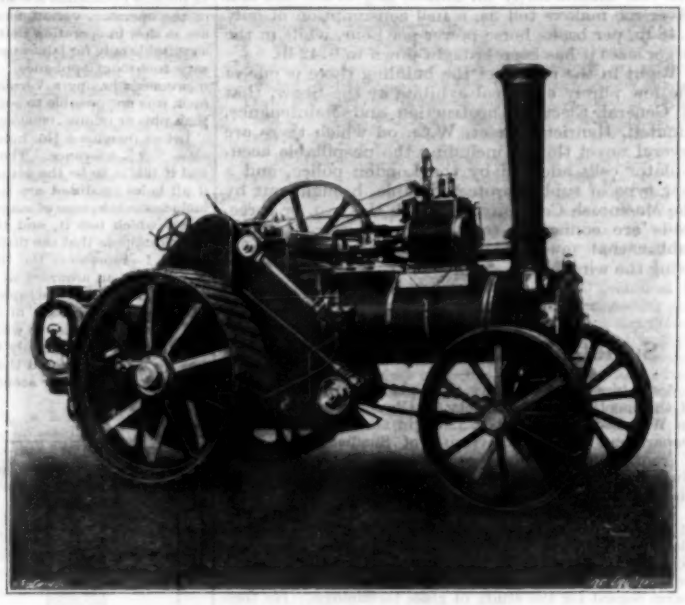


FIG. 5—AVELING AND PORTER TRACTION ENGINE

FIG. 6—FOSTER STEAM TIPPING WAGON

Peter Brotherhood, Peterborough, are showing a 30–35 horse-power paraffin oil ploughing tractor of the same type as that which we described in connection with the recent Royal Show, but which has now been fitted with a new vaporiser warmed by the exhaust gases, together with a 1-kilowatt Bull electric lighting set. This set is driven by a single cylinder, four-stroke, petrol engine, having a cylinder 2¾in bore by 3in. stroke, fitted throughout with ball and roller bearings, and lubricated on the splash principle. The inlet and exhaust valves are mechanically operated. The cylinder is water jacketed, and the head can be removed for cleaning the water jacket. The engine can be supplied to work on town gas and a specially designed gas and air mixing valve is then supplied in lieu of the carburetter.

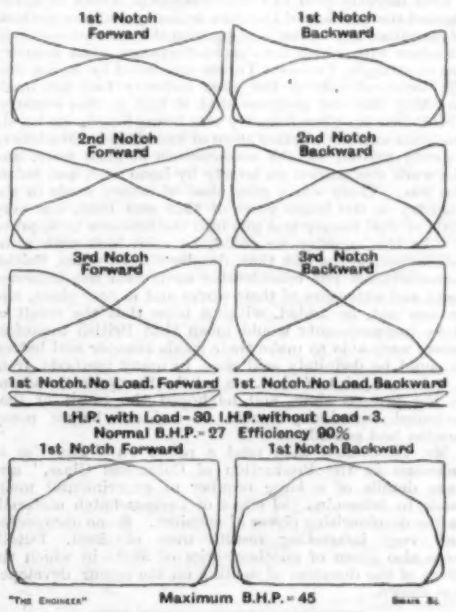

1st Notch Forward
1st Notch Backward
2nd Notch Forward
2nd Notch Backward
3rd Notch Forward
3rd Notch Backward
1st Notch. No Load. Forward
1st Notch. No Load. Backward
I.H.P. with Load = 30. I.H.P. without Load = 3.
Normal B.H.P. = 27 Efficiency 90%
1st Notch Forward
1st Notch Backward
"The Engineer"
Maximum B.H.P. = 45

FIG. 7—CARDS FROM AVELING TRACTION ENGINE

John Fowler and Co., Limited, Leeds, are exhibiting typical examples of their ploughing machinery, including the 60 horse-power motor-driven equipment we have already described and a new type of subsoil plough, while Clayton and Shuttleworth,

Limited, Lincoln, have a compound steam traction engine, a thrashing machine, a new type of chaff cutter, and a 20 horse-power two-cycle crude oil engine. Blackstone and Co., Limited, Stamford, exhibit a variety of oil engines; and Wallace (Glasgow), Limited, Glasgow, are showing a petrol lighting set and a tractor which we have already dealt with.

The principal exhibit on the Ruston and Hornsby stand, which this year is merged into one, is a 15 brake horse-power oil engine, which can be started from cold, even in winter weather, without the use of a blow lamp. This feature is made possible by the use of a fairly high compression, but not so high as that adopted in the Diesel engine. These engines will run satisfactorily on almost any crude oil, and have, the makers tell us, a fuel consumption of only 0.48 lb. per brake horse-power per hour, while in the larger sizes it has been brought down to 0.42 lb.

Right in the corner of the building there is one of the few purely electrical exhibits at the Show, that of General Electric Construction and Maintenance, Limited, Henrietta-street, W.C., on which there are several novel things, including the unspillable accumulator cells adopted by the London police, and a new type of rubber protected cable, brought out by the Macintosh Company, in which the two, or three, leads are connected together by a web of tough rubber that must be of considerable assistance in fixing the wires.

Society of Glass Technology.

AN interesting ceremony took place in the early part of the meeting of the Society of Glass Technology, held on Wednesday, November 22nd, in the Applied Science Department of the University of Sheffield, when the "Frank Wood" Medal was presented to the successful students in the Department of Glass Technology at the Sheffield University.

Mr. W. M. Gibbons, Registrar of the University, who attended on behalf of that institution, said that they all liked to think that the Society of Glass Technology was born in the University, and they were glad at all times to welcome it in their midst. The University had a very warm regard for the study of glass technology. He then went on to explain that in 1919 the Society decided to recognise the services Mr. Frank Wood had rendered in connection with its foundation and handed over to the University a hundred guineas, with the condition that the income should be utilised to provide some reward for students in the glass technology department. It was decided that the reward should take the form of a medal, and that it should be associated with the name of Mr. Frank Wood, in whose honour it had been established. The medal had been designed by Mr. Percy Metcalfe, of the Royal College of Art, at the suggestion of Professor Rothenstein. Mr. Frank Wood then presented the medal to the successful students, Mr. G. G. Middleton and Mr. H. W. Howes, and in doing so expressed appreciation of the honour that had been done him by associating his name with the medal, and asserted that Dr. Turner had been the real backbone of the Society.

Professor Turner subsequently gave a short account of a visit recently paid to Czecho-Slovakia, where he investigated the position of the glass industry and the methods of manufacture. After dealing with the difficult economic situation with which the Czecho-Slovakian glass industry has to struggle, Professor Turner concluded by saying that the technical side of the glass industry had not made anything like the progress that it had in this country. The Bohemian glass industry was living largely on its old tradition and the existing store of knowledge. Machinery scarcely existed for the manufacture of glass ware, and the work was carried on largely by hand as it was before the war. There was a great deal of money made in the industry in the boom years of 1919 and 1920, but very little of that money was put into the business to improve it. In this country we could, he said, look with some satisfaction to the fact that, despite E.P.D. taxes, British manufacturers put considerable sums into the improvement and extension of their works and in new plant, and he was not, he added, without hope that the result of these improvements would mean that British manufacturers were able to make their goods cheaper and better. It could be definitely said that, in many methods, from a technical point of view, we led the European Continent at the present time, and he hoped the result of that technical superiority would be evident before many months had passed.

Mr. A. Cousen then read a paper on "The Use of Selenium in the Production of Colourless Glass," and gave details of a large number of experimental melts made to determine the effect of various batch materials on the decolourising power of selenium. Some unexpected and very interesting results were obtained. Details were also given of another series of melts in which the effect of the duration of melting on the colour developed was shown.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

ERRORS OF GAUGING.

SIR,—I would like to call your attention to the state of affairs which exists in the majority of engineering works in this country which profess to manufacture products which are interchangeable and to definite limits.

The tolerances on the work are usually first of all fixed by the drawing-office without proper consultation with the works. The gauges to check the article are made by the works toolroom as near as they can be got with a micrometer set up to slip gauges. The gauges are issued to the shop and the work is produced to them,

It is well to examine exactly what happens under these conditions. The first axiom in limit gauging is that for any particular fit or functioning of the component there is only one maximum tolerance which will produce this. Secondly, that the tolerance available in the shop will be less than the maximum tolerance by the tolerance of manufacture of the "go" and "not-go" gauges and wear allowance of the "go" gauge. Both the tolerance of manufacture of the gauges and the wear allowance of the "go" gauge depend upon accurate standardisation.

Under usual conditions the firm is not equipped with any type of measuring machine, or if it is, this is put in a glass case and never used except to impress visitors who are shown over the works. Therefore, transference of size from slip gauges by means of micrometers is the only method of standardisation that is available.

This is generally due to the fact that the measuring machines at present obtainable are so influenced by the personal element of the operator, variations of temperature and vibration, and are so slow in operation that the practical man looks upon them as suitable only for laboratory experiments instead of as a necessary tool-room appliance. With the most skilled man and a micrometer having a Vernier reading of ten-thousandths of an inch, it is not possible to get an accuracy of transference greater than plus or minus .00005in.

Let us imagine a 1in. hole which is to be produced to Newall class "A" tolerance. The tolerance on the hole is .0005in., and if this is to be the actual tolerance of functioning—that is, if all holes produced are to lie within this tolerance—it must include the tolerance of manufacture of the "go" and "not-go" gauge which test it, and the wear limit of the "go" gauge. Let us suppose that the distance between the two lines A and B —Fig. 1—represents the true tolerance of .0005in. available. If we allow an accuracy of .0001in. on each end of the gauge and a wear limit of the same amount on the "go" end, we may have absorbed .0003in. of our tolerance, and when the gauges are new the tolerance to which the product has to be made may be as low as .0002in.—only 40 per cent. of the original tolerance; but we have just stated that a micrometer transference of size cannot have a greater accuracy than plus and minus .00005in.

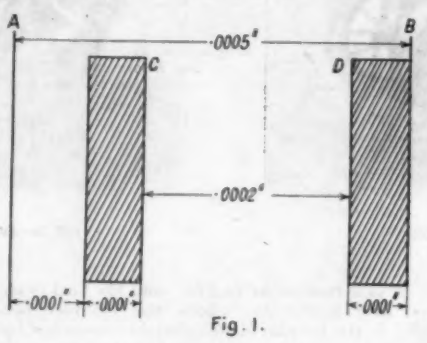


Fig. 1.

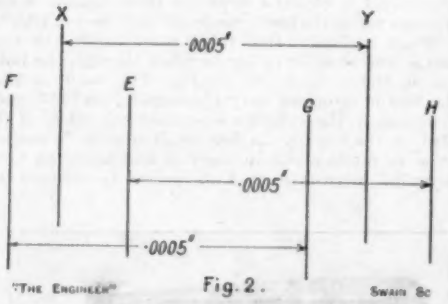


Fig. 2.

It is therefore impossible to make gauges accurate to .0001in., so that the very small tolerance to which the product must be made is still further reduced or may be completely absorbed. Unless extremely accurate means of transference of size are available it is impossible, using ordinary commercial methods and limit gauges, to work to such tolerances as Newall Class "A" for small holes.

The effect of lack of accuracy in transference of size can be shown in another way. Suppose the distance between the lines X and Y—Fig. 2—to be the tolerance of .0005in., neglecting all questions of wear limit and manufacturing tolerance on the gauge, if the distances X F, X E, Y G, and Y H all represent .00005in. (the transference error using a micrometer), it is clear that the "go" and "not-go" end of the gauge may be anywhere between the lines F and E and G and H, the extreme positions, still maintaining the difference of .0005in. between the ends, being F and G and E and H. This is a variation of .0002in., which must be deducted from the maximum tolerance, leaving only .0003in., which will be absorbed by the tolerances of the gauge and the wear allowance.

We have now absorbed the entire limit of .0005in. in errors of standardisation, tolerance of manufacture on the gauge and wear limit, and no factory which uses micrometers and slip gauges as a means of standardisation can do any better, and, what is still more, the absorption of the tolerance due to errors of standardisation will not be apparent. What actually does occur is that the tolerance is very much increased, the tolerance available for the shop still being kept at .0005in. and the errors of standardisation, manufacture of the gauges and wear limit of the "go" end of the gauge piled on on the outside. The works find that the articles still function satisfactorily, and know intuitively when the gauges should be scrapped and new ones made; and so year after year the article is produced at very often double and sometimes, in the case of fine tolerances, three times the tolerance placed on the blue print. The articles still function satisfactorily and therefore the full tolerance worked to could be employed; but the tolerance on the blue print is not altered, whether from false pride of workmanship or a misunderstanding of the principles involved.

It is obvious that this state of affairs wastes money, since the smaller the tolerance available in the shop the greater is the cost of manufacture, and if the maximum tolerance to which the work would function satisfactorily could be fixed and standardised accurately so that a maximum tolerance would be available for the gauge manufacturer and also for the shops in making the component, money would be saved all round.

If standards of extreme accuracy were not available there might be some excuse for the present state of affairs; but they are available. Slip gauges can be purchased which have a guaranteed error well inside plus and minus .00001in. It is the connecting link—that is, the means of transferring these sizes on to the gauges being made—which at present is missing.

It is obvious that the whole quality of output of a grinding machine depends upon the accuracy of its control; given the most accurate grinding machine in the world, and no means of standardisation, no gauges could be produced, the accuracy of the product depending entirely upon the standardisation available.

Another difficulty that is met with, due to this false conception of tolerances worked to, is the fact that firms, which beforehand have not been in the habit of working to limits, when wishing to do so are given these fictitious tolerances for their products, and when they make a genuine attempt to work to them, disappointment is the result, and they go back to their old methods of production.

We have in the engineering world a far too exalted opinion of our fine tolerances, and the majority of firms who work on an interchangeable system merely have one which is temporary; that is, components produced in approximately the same three months will interchange correctly, but a component produced two years hence will very likely not. This is most largely due to inaccurate standardisation.

Standardisation may be regarded as a base line from which all tolerances are derived. We know that a tolerance exists only as a distance between two bounding dimensions, and it is obvious that the more clearly the distance between the boundary lines can be fixed the more space is available inside, and also the more definite the position of the base line the more nearly can we fix the position of the boundary lines.

A simple analogy can be drawn in the marking out, let us suppose, of an ordinary tennis court. The first thing we must be careful of is to get the court the right size, i.e., the two end lines must be a definite distance apart. This error in gauging will be our tolerance of manufacture of the gauges and our wear allowance; but we have a further problem which is not present in marking the tennis court: not only must we have the court the right size, but we must put it in the proper place, and it is here that our errors of standardisation creep in when speaking of gauges.

It is obvious that the only reason for defining limits is to cheapen production, and, therefore, since the cost of production is to-day of prime importance, proper tolerances cannot be neglected.

Going back to our original diagram, Fig. 1, what is happening is that the tolerance specified on blue prints, &c., is the tolerance C D, the shop being allowed its latitude of wear and inaccurate standardisation outside; whereas, of course, the tolerance stated should be that of A B, since the latitude allowed the shop is an unknown and variable quantity, making the tolerance similarly unknown and variable.

AXEL. C. WICKMAN.

Coventry, December 2nd.

ROYAL INSTITUTION.—The Juvenile Lectures at the Royal Institution this Christmas will be delivered by Professor H. H. Turner, whose subject is "Six Steps up the Ladder to the Stars." The first lecture will be given on Thursday, December 28th, on "The Distance of the Stars," followed by "The Discovery of the Planet Neptune," "Photographing the Stars," "The Spectroscope and its Revelations," "Two Great Streams of Stars," and "The Size of a Star." The following are the lecture arrangements before Easter:—On Tuesday afternoons, commencing January 16th, there will be two lectures by Professor F. G. Donnan, on "Semi-Permeable Membranes and Colloid Chemistry," two by Mr. R. D. Oldham on "Earthquakes," two by Professor A. C. Pearson on "Greek Civilisation and To-day," two by Sir Arthur Shipley on "Life and its Rhythms," and two by Professor C. G. Seligman on "Rainmakers and Divine Kings of the Nile Valley." On Thursday afternoons, the Hon. J. W. Fortescue will give two historical lectures, beginning on January 18th; Professor I. M. Heilbron two on "The Photosynthesis of Plant Products;" Professor B. Melvill Jones two on "Recent Experiments in Aerial Surveying," and Mr. Theodore Stevens two on "Water Power of the Empire." On Saturday afternoons, commencing January 20th, there will be two lectures by Sir Walford Davies on "Speech Rhythm in Vocal Music;" two by Mr. J. C. Squire on "Subject in Poetry," and six by Sir Ernest Rutherford on "Atomic Projectiles and their Properties." The first Friday evening discourse will be delivered by Sir James Dewar on January 19th on "Soap Films as Detectors of Stream Lines, Vortex Motion and Sound." Succeeding discourses will probably be given by Sir Almroth Wright, Mr. C. F. Cross, Sir John Russell, Dr. A. V. Hill, Professor A. S. Eddington, Dr. G. C. Simpson, Dr. M. R. James, Sir Ernest Rutherford, &c.

ELECTRODES FOR WELDING COPPER, BRONZE AND BRASS.—Three types of electrodes are now manufactured by Alloy Welding Processes, Limited, for the purpose of welding and depositing non-ferrous metals. The non-ferrous "A.W.P." electrodes are manufactured on the same principle as the firm's ferrous "A.W.P." electrodes. The metal core of the non-ferrous electrodes is of pure copper. It is surrounded by a flux covering which adheres firmly to this copper rod and does not, the makers state, break away when subjected to transport and workshop usage. This flux covering is of special composition to suit the nature of the copper alloy to be welded, and it is intended to produce a powerful reducing atmosphere around the work so as to ensure good metal being deposited in the weld. Copper and the various alloys of bronze and brass in general use have a very short temperature range between the welding and fusion points, and practice is necessary to prevent the metal becoming fluid or remaining in a sluggish condition. Care has, therefore, to be taken to prevent piercing of the parts being welded by excessive heating. Furthermore, the heat conductivity of copper is very high, and the deposited metal will impart its heat to the job, thus making good amalgamation difficult at the commencement of the weld, unless it is pre-heated to a sufficiently high temperature. Hence, as the makers point out, it is advisable when using non-ferrous "A.W.P." electrodes to pre-heat the work before starting the welding operation. In the majority of cases local heating applied by a blow-pipe along the line of weld is, it is said, sufficient. Whenever possible, the joint to be welded should be supported underneath by some refractory material, such as carbon, asbestos millboard or furnace lining material. By understanding these characteristics of copper, and observing the precautions indicated, it is claimed that no difficulty will be experienced in welding copper, bronze and brass satisfactorily. It is not apparently necessary or advisable to hammer the metal deposited with these non-ferrous electrodes, as it is said to be perfectly homogeneous and free from blow-holes. The warning is given that as the fumes from molten brass and copper are dangerous to health, special precautions should be taken when using the electrodes in a confined space.

Railway Matters.

REDUCTIONS in the rates for the conveyance of the raw materials of the iron and steel trade came into force on the 1st instant.

THE Bill which the London and South-Western Railway Company is depositing covers powers which are being sought by the London, Brighton and South Coast Company.

THE Great Western Railway Company is seeking for powers to purchase the railways and docks of the Swansea Harbour Trustees. It will then control all the ports in South Wales.

IT is a long time since the Midland Railway Company had a Bill before Parliament for any new works beyond that, promoted jointly with the Port of London Authority, last session, for the floating dock at Tilbury. It is now seeking powers to widen the line for 3 miles 5 furlongs in the neighbourhood of Sandal and Walton stations between Sheffield and Leeds, and for 2¼ miles in the neighbourhood of Bromsgrove.

A PASSENGER train of the Wirral Railway Company, from West Kirby, came into collision with one bound for that destination at Birkenhead Park Station on Wednesday afternoon last. A passenger seated in an invalid's chair in the guard's van of the latter train died subsequently from shock. This is the first accident to a passenger train on the Wirral Railway in which a passenger has been killed, and is the third fatal passenger train accident on British railways this year, and brings the total number of passengers killed in train accidents to five.

THE size and importance of the New South Wales Government railway system is shown by the fact that it embraces a track mileage of 6742 miles, all of which is on the standard 4ft. 8½in. gauge. Nearly £90,000,000 have been invested in the system. During the last financial year the railways earned a total revenue of £15,213,019, and the total working expenses incurred amounted to £11,116,302. The surplus of earnings over working expenses of £4,096,717 thus shown was paid into the consolidated revenue of the country to assist in bearing the burden of interest on the National Debt.

BY an Order made on November 7th, 1911, railway companies owning less than 3000 wagons were given ten years in which to equip their wagons with brakes on either side; companies having between 3000 and 20,000 wagons had fifteen years, and those with over 20,000 were given twenty years. One result of the grouping of the companies is that whilst some of the constituent companies had under 20,000, and thus had to complete the work by 1926, under grouping they will get the maximum time. Joint companies like the Cheshire lines, Midland and Great Northern and the Somerset, which remain outside the grouping scheme, get no such extension.

AMERICAN railways are experiencing the worst "car shortage"—failure to supply wagons for which loads are ready—ever known. Farmers are waiting to load grain, potatoes, fruit and other crops, and a very acute situation has arisen, especially as cold weather is setting in. It is, we believe, partly the result of a policy of the companies to postpone repairs until labour and material were cheaper, and partly the result of cars getting out of order through want of attention during the shopmen's strike. These shopmen, by the way, are not workmen employed in the shops, but mechanics on the line who examine, clean and lubricate locomotives, cars, &c.

THE Lithuanian Government is now completing the construction of a 59-kilometre line from Kazlu Ruda to Sestakavas for the purpose of linking up the Varena-Alytus-Sestakavas railway with the main Lithuanian network and of providing railway communication to two such important points as Kalvarija and Mariampole. A feature of this undertaking is that much of the material has been collected from masses of *débris* originally forming part of bridges, rails, &c., destroyed during the war. For example, on one stretch all the requisite iron, which formerly belonged to a railway bridge opposite Alytus, was recovered from the waters of the Niemen River. Although the work of collecting this material absorbed a large amount of labour, very appreciable economy was affected, since to buy the same quantity on the ordinary market to-day at current prices would have involved a heavy outlay.

THE railway companies, the Press Association learns from an official source, have asked the two railway unions—the National Union of Railwaymen and the Associated Society of Locomotive Engineers and Firemen—for a further conference to discuss the proposals for varying the existing national agreements. The meeting was expected to take place some time this week. There is every likelihood that negotiations will be resumed. The proposals made recently by the companies were rejected by the unions. It was anticipated that the next step of the companies would be to make their application to the Wages Board, but apparently they have decided to make a further effort to reach a settlement by direct negotiation with the unions. It is not yet known whether the companies have varied the demands which the unions rejected or whether they are prepared to do so if negotiations are resumed.

A MEETING of the proprietors and debenture stockholders of the Great Western Railway will be held on the 15th instant to approve the terms for the absorption of several more railways. We have seen it stated that these meetings will nearly complete the Great Western Railway Group, and that one still outstanding is the Forest of Dean Central, a scheme for which will be settled by the Amalgamation Tribunal. We agree as to the latter. We have never been able to obtain any information as to this line. The railway in the Great Western Group about the future of which we shall be interested to hear is the Midland and South-Western Junction. Its allocation to the Great Western was somewhat of a surprise. It has physical junctions with that system at three places, one of which is at the northern end, but it has closer business relations with the Midland and the London and South-Western. It affords the Midland a through route to Southampton, and, moreover, owes that company £244,000 for money advanced, together with £95,390 interest thereon.

Notes and Memoranda.

THE new No. 3 shaft of the Springs gold mine, Transvaal, is capable of handling 50,000 tons per month, and this could practically be doubled if necessity arose, but it is unlikely that such a tonnage will be called for in the near future.

A NEW device for blowing forge fires, &c., has recently been introduced in Canada by the Canadian Ingersoll-Rand Company. A tiny jet of high-pressure air discharges into a bell-mouth nozzle leading to the forge and induces a flow of air from the atmosphere into the nozzle, where it mingles with the expanding jet and is propelled into the pipe leading to the forge, providing the proper volume of air at a suitable pressure for the purpose. The use of the device is said to have resulted in a considerable annual saving.

A NEW method of charging batteries for electric vehicles, described in the *Electric Vehicle*, is claimed to reduce the initial outlay on charging equipment and also to obviate loss of power. A five-wire balancer is used. Unlike the motor generator, it is not called upon to transform the total energy consumed, but deals only with a small fraction thereof. When the load is balanced it simply runs idle across the 440-volt mains and takes little power, but is continually in readiness to see that no one leg of the five-wire circuit gets a higher pressure than 110 volts.

IN a note headed "Russian Electric Ploughs," the *Electrical Review* of November 24th states that the Elektrozem is undertaking a number of experiments on a large scale with electric ploughs prepared by the Briansk works, in the district of Bogorod, where 250 dessiatines of land will be ploughed up. Experiments will be undertaken in other districts, where deep ploughing is required and where the land is very heavy, requiring careful ploughing for sugar growing. Agreements are also being drawn up for the electrical equipment of farms.

LEAKS, caused by corrosion, in a large water main in America were stopped by electric welding without cutting off the water, which had a pressure of 90 lb. per square inch. The process, described in the *Engineering News-Record*, was as follows:—Where a hole in the pipe was discovered the flow of water was stopped with a pine plug. The plug was then cut off flush with the surface of the pipe and covered with a metal cap held fast by tacking it on the side with an electric arc. The cap used was of metal of approximately a No. 11 gauge and was slightly concave. Over this cap metal was welded, extending far enough to get a firm hold on the pipe.

AT the beginning of this year the copper ore resources of the Tanganyika Concessions Company in Belgian Congo were estimated at 65 million tons, containing about 4½ million tons of copper, and it is believed that further exploration may increase this figure. Some 30,464 tons of copper—a figure which was higher than that of any other copper-producing company—were produced in 1921 as compared with 18,962 tons in 1920. During the first six months of 1922 nearly 20,000 tons of copper were produced. Special attention has been given to the treatment of poor quality ore by the electro-chemical process, an experimental station designed to produce 1000 to 2000 tons per annum, the motive power of which is to be provided by harnessing the waters of the neighbouring rivers, having been established with encouraging results.

IN the course of a study of hearth gases from blast-furnaces, being made by Mr. G. St. J. Perrott, of the United States Bureau of Mines, at Birmingham, Alabama, the results of sampling hearth gases have so far shown no difference in the combustibility of different cokes in the hearth of four blast-furnaces. There is a difference in the rate of reaction of different kinds of coke with carbon dioxide at 1000 deg. Cent. These results corroborate the combustion experiments that are being carried on in the Kreisinger furnace. The suggestion has been offered that combustibility tests be made in a small furnace at the lowest possible rate at which combustion may be maintained in order to determine whether there is a different influence of the various kinds of coke on the rate of combustion at low temperatures.

ANOTHER achievement in the history of wireless communication must be placed to the credit of the Marconi International Marine Communication Company, Limited. The great White Star liner Majestic, which arrived at New York recently, on approaching New York, cleared its Marconigrams to the Chatham (Mass.) wireless station with high-speed automatic transmitting apparatus, this being the first time that automatic wireless transmission has been used from a liner. This innovation was made because of the large number of business and private messages which Transatlantic passengers desire to send when approaching America. The Majestic is the first liner to be equipped in this manner, but it is probable that other liners will also have automatic transmitters installed shortly. The maximum speed of the automatic apparatus used is 240 words per minute.

"THE Efficient Control of Super-power Stations, with Special Reference to Heat Balance," was the subject of a paper recently read by Mr. John Bruce before the members of the local branch of the Association of Mining Electrical Engineers at Glasgow. The paper dealt with the distribution and destination of the heat units liberated by the combustion of coal. It was thought, the author stated, that with the extended use of oil fuel during the last coal miners' strike many undertakings would be able to supply reliable data concerning the results obtained with that fuel, but the time was too short for conclusive results to be arrived at, as, owing to the very high cost of oil, users were glad to go back to the comparatively cheap coal fuel. After describing the various available methods of furnishing auxiliary power, and at the same time controlling the heat balance, Mr. Bruce said that the results at Dalmarnock compared very favourably with those obtained in super-power station practice in America. Operating figures for similar stations in this country were difficult to obtain, the designers and engineers concerned being exceptionally conservative in the matter of making public results so far obtained. The figures revealed the efficiencies of the numerous stages between the coal and units generated.

Miscellanea.

THE Government of Madras has sanctioned the grant of a concession to make use of the water in the Pykara and Avarni Halla Rivers in the Nilgiris district for the generation of electrical energy for industrial purposes.

A DOCK for the new petroleum port is now being built on a site forming part of the Budapest winter harbour. The length of the quays is about 1400 m. Two important oil companies have already established quarters near the port.

THE window in memory of the late Sir John Wolfe Wolfe Barry, K.C.B., F.R.S., past-president Inst. C.E., which has been erected in the nave of Westminster Abbey, was dedicated by the Dean of Westminster on Thursday, December 7th.

THE Mining Department of the University of Sheffield has put down a mining laboratory on up-to-date lines. Among the work now being carried out is research into the flame-proofness of electrical apparatus in mines, the results of which are proving of great service to the industry.

IT is stated that a radical change of plans may be found necessary regarding the situation of the proposed grain elevator at Durban, Natal. The instability of the site at Congella threatens to defy the best efforts to provide a sound foundation, and another site will have to be found, probably on the right-hand side of the entrance to the new graving dock.

WE are informed that the Society of Technical Engineers has now in active operation a very interesting scheme of unemployment insurance for those of its members who wish to take advantage of it. The scheme, which is designed on simple but practical lines, was first tried experimentally in one of the largest branches, but has now been extended to the whole Society. Particulars of the scheme may be had in detail on application to the secretary, 102, Belgrave-road, London, S.W. 1.

AT a recent meeting of the London County Council Mr. Harris moved the following resolution:—"That it be referred to the Public Control Committee to consider and report how far fog in London is caused by the pollution of the atmosphere due to preventable causes; whether by a larger use of electricity for power and other purposes the atmosphere of London might be improved, and whether any and, if so, what further powers are required to deal with the emission of smoke in London."

A REPORT from New York states that successful demonstrations were made on December 5th with a tank equally at home on land and water. Along Riverside-drive it attained a speed of 30 miles an hour. For this, rubber-tired wheels were used. Using caterpillar wheels, it climbed a gradient of 1 in 2½ on the slopes of the Palisades in New Jersey and, with propellers attached at the rear, entered and crossed the Hudson River, a distance of a mile and a-quarter, under its own power to New York City. The tank carried a 3in. gun and a supply of ammunition.

THE deed for the formation of the syndicate for the canalisation of the Moselle as a limited liability company with a capital of 500,000 francs, has been placed with three notaries of Metz. The aim of the company is to promote the canalisation of the Moselle by all means in its power, more particularly by advancing to the State the sums necessary for the execution of the work. These sums will be obtained by loans. The Prefect of the Moselle has expressed the hope that the first work in connection with the construction of the canal may be begun in the spring.

INFORMATION has just come to hand that at a meeting of the Rand Water Board, held on September 29th, it was decided to proceed with the second unit of the Vaal River scheme—described in our last issue—at an estimated cost of £501,190, to provide an additional 5,000,000 gallons of water a day. Amongst the items of estimated expenditure are pipe lines, £389,340; precipitation tanks, filters, and sterilising plant, £41,715; additions at the Vereeniging main and river pumping stations, £36,050; and service reservoirs, £15,450. It is anticipated that recent contracts for pipe lines, &c., in connection with the first unit of the scheme will be duplicated.

ALTHOUGH the report of the American mining engineers who recently inspected the Manchurian coal and iron fields has not yet been made public, it is reported in the *Iron and Coal Trades Review* that as a result of their investigation, the South Manchurian Railway Company will proceed with its original plan of erecting a large steel works in the Far East. The scheme as reported contemplates a consolidation of the Anshan Iron Mines and Steel Works operated by the South Manchurian Railway Company with the Penchihu Colliery and Steel Works, a Chinese-Japanese enterprise controlled by the Okura interests of Japan. The low-grade iron deposits in Manchuria are expected to yield profitable returns. The plant will be able to furnish all the steel products required for the extensions of the South Manchurian Railway system, and the Chinese Eastern and Siberian railways, as well as other enterprises in China proper.

IT has been decided that the task of finally allotting space at the British Empire Exhibition, not only to the respective groups, but to the various applicants within each group or section, shall not be undertaken before the New Year, and that—subject, of course, to the preference to be given to guarantors—all applications received up to the end of the present year shall be given full consideration. The importance of intending exhibitors sending in their applications before the end of December lies in the necessity of the Executive Council being informed whether or not adequate space has been provided. Already there is some talk of one of the two large halls having to be extended beyond the area at present planned. These buildings—the Machinery Hall and the Industrial Hall—cover a total floor area of 884,000 square feet, which is five times greater than the exhibiting space at Olympia. This relates to United Kingdom exhibits only; the Dominions will have their own pavilions, and will undertake their own organisation of exhibits.

NEW COAL WHARF AT DULUTH ON LAKE SUPERIOR

(*For description see page 593*)

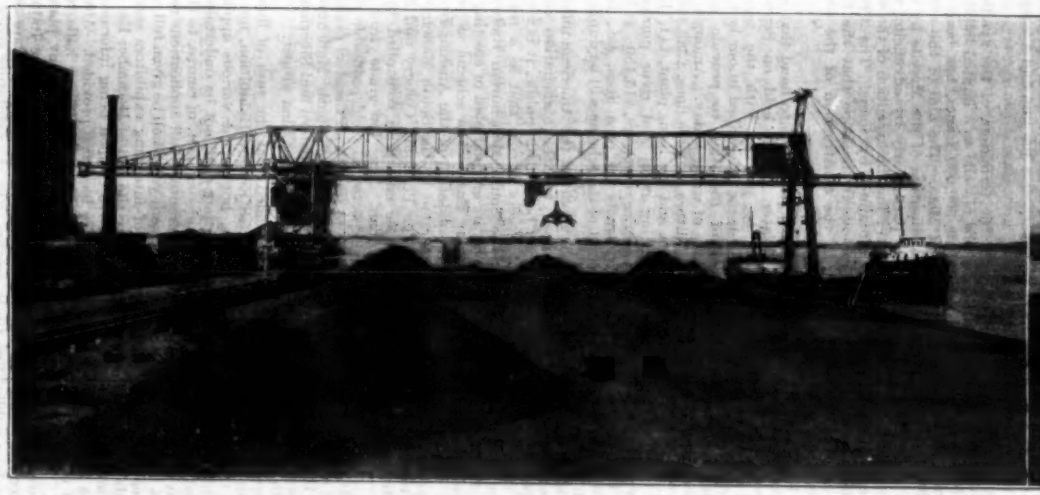


FIG. 2—VIEW LOOKING FROM THE SHORE END TO THE HEAD OF THE WHARF

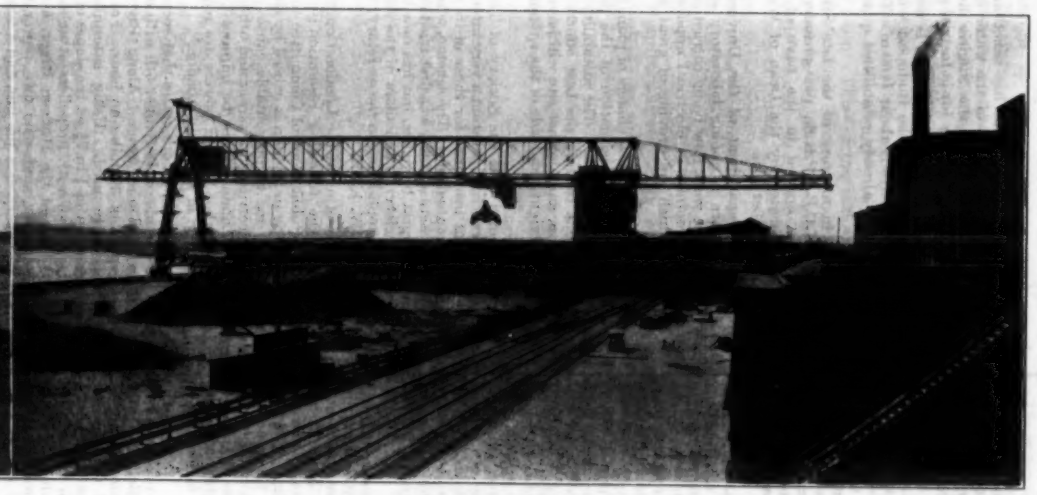


FIG. 3—VIEW LOOKING SHOREWARDS FROM THE WHARF HEAD

FIG. 4—SIDE VIEW OF THE WHARF, SHOWING A 600-TON COLLIER LYING ALONGSIDE

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THE ENGINEER.

DECEMBER 8, 1922.

The Theory of Lubrication.

THE ninth Thomas Hawksley Lecture, delivered at the Institution of Mechanical Engineers last Friday, must, we fear, be characterised, if we are to be frank, as disappointing. The crowded audience which assembled to hear Dr. Stanton's account of his recent researches on lubrication was testimony to the interest of members and their friends in the subject, but it is safe to say that of those present, few, save those who had made lubrication a subject of special investigation, could have given a clear account of what the lecture was all about. The practical engineer found in it, it may be accepted, little of direct value to him in his every-day work, and at the best it appeared to be taken up with a discussion on purely academic lines as to whether Osborne Reynold's mathematical interpretation of Beauchamp Tower's experimental results was right or wrong. That Dr. Stanton's investigations in general supported Reynolds' views was, no doubt, gathered by the bulk of the audience, but why they did so, and what significance was to be attached to the fact that they did, were, we venture to say, matters on which few of the audience would have cared to submit to an immediate cross-examination. We recognise that the subject was a very difficult one to submit to an audience composed, as regards a very small part only, of experts, and Dr. Stanton is to be heartily congratulated upon the fact that he held attention for an hour. But we are disposed to think that his lecture was given prematurely, that it would perhaps have been better had the Council delayed its invitation to the author till he had carried his investigations further. When he has completed the very exacting experiments in which he is engaged, we trust that he may be given another opportunity to lay the matter before the Institution, and that it may be then found that there is real value in results which now appear to be rather unconvincing and wholly without practical importance.

From the fairly full abstract of the lecture which we publish elsewhere in this issue, it will be gathered that the key to Dr. Stanton's recent researches was the differential equation which in 1886 Osborne Reynolds established for the pressure distribution in the film of oil in a lubricated semi-circular bearing. Reynolds worked on the assumption that the oil flow followed hydrodynamical laws and endeavoured to prove that his assumption was right by applying to his equation the experimental results obtained by Tower. The process involved was to integrate the pressure distribution over the arc of contact and to compare the result with the figure given by Tower for the total load on the bearing. Unfortunately, certain of the factors in his differential equation could not be deduced from Tower's figures without making considerable assumptions, but in the end a result was obtained which agreed with the recorded loads, and it was accordingly deduced that, with certain reservations, the lubrication of bearings of the type used by Tower was dependent upon hydrodynamical laws. Being so, it followed, from the theory, that the friction of a journal in its bearing was proportional to the viscosity of the oil, as, in general, practical experience showed it to be. Instances, however, were subsequently noted in which the friction was apparently independent of the viscosity, and, as a consequence, it became accepted that all lubrication was not of the Reynolds, or "perfect" type. Later researches by Deeley, Hardy, Archbutt and others led to the introduction of the conception known as "boundary" lubrication, in which hydrodynamical considerations played no part, the film of oil being so thin that the lubrication became a molecular, and according to some even a chemical phenomenon. This supposition explained many facts which could not be reconciled with Osborne Reynolds' theory. It explained why some metals were better than others for bearings, for it clearly postulated that in certain conditions of close proximity, the material nature of the surfaces influenced the frictional resistance as did the nature of the lubricant. It explained, too, why the friction was found at times to be independent of the viscosity of the oil, and why the addition of a small quantity of vegetable oil or fatty acid to a mineral oil made a mineral oil substantially as good as a vegetable oil without sensibly altering its viscosity. This theory was becoming widely accepted, but faith in it has now been shaken by Dr. Stanton. According to his results and his interpretation of them, he has proved to his own satisfaction that when the conditions are such that "boundary" lubrication ought to prevail, the film is actually several thousand molecules thick, and behaves hydrodynamically in accordance with Reynolds' theory. It is to be noted that while Dr. Stanton is ready with an explanation of why the friction of a bearing may be independent of the viscosity of the lubricant without conflicting with the theory of "perfect" lubrication, he has not, so far at least, explained away the phenomenon of bearing metals. His experiments were confined to the use of one material for the journal and one for the bearing, whereas completely to prove that "boundary" lubrication did not exist under the imposed conditions, he ought to have shown us that the results arrived at were independent of the material nature of the journal and bearing. Apart, however, from any such minor criticism, we are disinclined to accept Dr. Stanton's conclusions, because we feel that they have been arrived at by a logically unsound argument—a form of argument, in fact, by which one might almost prove that black was white. He started with an advantage over Reynolds in that certain factors in the problem—namely, the difference of radii between the journal and the bearing and the temperature of the lubricant between the surfaces—were, in some respects at least, directly measureable, and had not, as with Reynolds, to be inferred by a process which left considerable room for error. He could not, however, directly determine other factors, such as the excentricity of the bearing and journal, and had to discover them by applying Reynolds' differential equation to his experimentally determined curve of pressure distribution. From the factors, measured and inferred, he then calculated the nearest distance of approach of the bearing to the journal and showed that the thickness of the oil film at its thinnest point was far too great to meet the supposition that the lubrication was of the "boundary" type and was quite sufficient to permit "perfect" lubrication. But Reynolds' equation is based on the supposition that the lubrication is, in fact, of the "perfect" type. If therefore we make use of it in any way for the derivation of important factors affecting our problem, it would indeed be surprising if we succeeded in proving that the lubrication was other than "perfect." Hence, it seems to us a foregone conclusion that Dr. Stanton's calculated results for the pressure distribution would agree with the observed figures very closely. The wonder is that they do not actually coincide completely throughout the whole range. His method, if we rightly interpret it, led inevitably to the conclusion that the lubrication was of the hydrodynamical order assumed by Reynolds. The figures used to prove this contention were, in important measure, obtained by a previous assumption that the contention was right.

But even if Dr. Stanton's methods of arriving

at the conclusions given in his lecture were completely free from all question of doubtful logic, we would still hesitate to accept them as definitely settling for all time the theory of lubrication in circular bearings. In one of his tests with castor oil, the shortest distance separating the journal and bearing was given as 0.000046in., a distance which, he said, was sufficient to accommodate 4600 molecules of oil. That ordinary hydraulic flow, subject to the ordinary hydrodynamical laws, can take place in a layer of fluid of this tenuity is a statement which demands, we think, the corroboration of experimental evidence. Is it possible that the forces exerted by the moleclues of the journal and bearing penetrate insufficiently far into the molecules of the lubricant to have any effect on the frictional resistance to the rotation of the journal? Is it possible that there is a layer of oil in the interior of the film which is sufficiently free from the attraction exercised by the metal molecules to enable that layer to behave in accordance with the laws of hydrodynamics as applied to a fluid which is perfectly free from molecular attraction, except that arising from its own molecules? We cannot answer the question, and have only Dr. Stanton's word for it that in the space of 4600 molecular diameters, there is enough room for the hydraulic flow of some of the molecules unaffected by the surrounding external attractions. From the manner in which two Johanssen gauge blocks, when lightly smeared with a film of oil, the tenuity of which cannot be greatly different from that arrived at by Dr. Stanton, may be wrung tightly together we are justified in declining to believe without direct evidence that all boundary attraction is of insignificant influence on the flow at the centre of a film of oil 4600 molecules thick. Until it is established that it is negligible well before 2300 molecules are reached, it will be permissible, we think, for those who hold to the theory of boundary lubrication to continue to support it, and even, if they like, to cite Dr. Stanton's experiments in favour of their views.

The Domestic Load.

WHILST opinions may possibly differ as to whether papers such as that on "Domestic Load Building and Suggestions for Propaganda Work," read before the Institution of Electrical Engineers by Mr. W. A. Gillott on Thursday of last week, ought to be brought before a body composed of technical men, few will fail to perceive that the future prosperity of the manufacturing side of electrical engineering depends in no small measure upon the extent to which electricity is used in the home. Unless the much-discussed domestic load increases at the proper rate, makers of turbines, alternators and other power plant equipment cannot obtain their proper share of business, for although an immense amount still remains to be done in the way of applying electricity to industry and transport, there is also very great scope in the domestic field. It is therefore desirable in the interests of the supply undertakings and the manufacturers alike that due consideration should be given to propaganda work, but whether this work should be left entirely to engineers is quite another matter. There are, of course, men in the electricity supply business who have both engineering and commercial ability, and who have done good work on the commercial side of various undertakings. On the other hand, it is not difficult to find instances in which progress has been slow and unsatisfactory, and whilst it would not be right to generalise and attribute all backwardness to the same cause, there is not much doubt, we think, that lack of progression has often been due to men at the head of affairs having no commercial instincts.

There was perhaps some justification in the past for the chief engineer of an electricity supply station being called upon to run the complete concern. In the early days of small stations, and when lighting was the only class of business that called for consideration, it was perhaps scarcely worth while to employ well-paid people to search for means of augmenting the load, but in view of the present many applications of electricity, it would seem that the time has arrived when every supply undertaking of importance should have a proper business-getting organisation with a good show-room and other facilities for propaganda. Just as many of the supply undertakings have neglected the domestic load, so have they overlooked the possibilities of the electric vehicle, which at present is badly handicapped by the lack of proper charging facilities, and in some instances by unduly high charging tariffs. As is well known, electricity is employed extensively for domestic purposes in Canada and the United States, where the supply companies have very extensive show-rooms in which prospective customers can see apparatus in actual use before purchasing it. In those countries, the introduction of electric light into the home has been followed up by very active propaganda carried on by salesmen of electrical accessories, such as radiators and cooking appliances. It is, however, to be remembered that in those parts gas had not in many instances become entrenched when electricity was first introduced, the growth of most of the cities having been coincident with the electric era. Here, of course, the electricity supply undertakings are faced with severe competition. But that competition must be regarded as only adding another reason why electricity supply should be properly managed on the commercial side. The gas companies are at the present time leaving no stone unturned to retain the business which the electricity supply people are out to capture, and their publicity campaign is of a vigorous and far-reaching character. Considering the lines upon which many of the electricity supply systems have been run in the past, it is surprising, in view of the competition which they have had to face, that they have been able to make any headway at all.

Many an engineer has in the past had to run his station with an inadequate staff, and has had no time to think about developing a domestic load, whilst others have had no inclination to do so, their engineering training and scientific instincts having rendered them quite indifferent to the commercial aspect of the business. Added to these difficulties and misfortunes, there are, of course, political conditions which prevent certain undertakings from supplying appliances under the hire-purchase scheme, which is undoubtedly a great help in the direction of establishing a domestic load. One of the main obstacles to many who desire to use electricity in their homes is that of finding the requisite amount of money to carry out the wiring and buy the necessary equipment, and still have enough left to pay the tax collector. There is no doubt that if the hire or hire-purchase system were more generally adopted by the electricity supply undertakings, it would encourage the electrical industry, for domestic load building would be a less difficult job. There is much to be said for Mr. Gillott's suggestion that in many instances the use of small electrical appliances should at first be encouraged, for such articles are relatively inexpensive and serve quite well to give the user some idea of the advantages of electricity in the home. The "all-electric age" is still a long way off, but its advent can be greatly accelerated if the best technical and business brains are applied in the proper channels.

The Theory of Static Friction.

By R. M. DEELEY.

ALTHOUGH much has been learned of late years concerning the manner in which static friction varies with the nature of the surfaces, the nature of the lubricant between them, and with the load, it cannot be said that any theory has been considered satisfactorily to account for the facts. In these circumstances it is impossible to do more than give an outline of a tentative theory which may account for the phenomena met with.

Amontons found from his experiments in 1699 that the resistance to relative motion of solid surfaces in contact was independent of the area of contact and proportional to the normal load; but erroneously concluded that it should always be one-third of the total pressure. This law of friction must have been known to builders and architects for very many centuries; for it is a matter of common knowledge even to uneducated mechanics that bodias are stable on certain slopes, whatever the weights or surface areas may be. Recent experimental work has proved the correctness of the views of Amontons with regard to the relationship between friction, load and area; but has shown that the coefficient of static friction varies greatly between different substances. In an unpublished note-book, Leonardo da Vinci[1] recorded how he had measured the force needed to move a rope when coiled closely in a ball and when stretched out to its full length, and found the pull to be the same, although the area of contact was different, and thus clearly anticipated Amontons' results, but Amontons carried out such a careful series of experiments, and so clearly proved the law of the relation of static friction to load and area, that it is only just to name this first law of friction after him. Amontons also concluded that the frictional resistance was due to the interlocking of the asperities of the surfaces in contact. Coulomb undertook in the arsenal at Rochefort a very extensive series of experiments, which he afterwards published in 1781, under the title of "Théorie des Machines simples, en ayant égard au Frottement de leurs Parties, et à la Roideur des Cordages."[2] He confirmed the law of Amontons with regard to the close dependence of the friction upon load, and also took the view that the friction was due to surface asperities.

Herschel's conception of the structure of a polished surface was, no doubt, similar to the view Amontons held at an earlier date.[3] Herschel expressed the view that "the process of polishing is, in fact, nothing more than grinding down of large asperities into smaller ones by the use of hard gritty powders, which, whatever degree of mechanical comminution we may give them, are yet vast masses, in comparison with the ultimate molecules of matter, and their action can only be considered as an irregular tearing up by the roots of every projection that may occur on the surface. So that, in fact, a surface artificially polished must bear somewhat of the same kind of relation to the surface of a liquid, or a crystal, that a ploughed field does to that of a delicately polished mirror." With the aid of a microscope the late Lord Rayleigh[4] followed the changes that occur in the surface in the process of polishing, and he came "to the conclusion that in all probability the operation is a molecular one, and that no coherent fragments are broken out." This view was converted into a practical certainty by Beilby, who proved that in the act of polishing the molecules are momentarily freed from constraint by the work done upon them, and then behave as the molecules in a liquid surface do under the action of superficial forces. Asperities, as understood by Amontons and Coulomb, do not therefore exist, and we must regard static friction as an action taking place between molecules or atoms subjected to greater or less conditions of restraint.

When two polished surfaces are brought into contact, with a lubricant between them, the adsorbed layers of the lubricant are the actual contact surfaces, but the nature of the contact is not quite that which obtains in the interior of a solid, even though the adsorbed films, like the surfaces they cover, are in a solid condition. Two clean, polished solid metallic surfaces, when brought into contact, do not adhere appreciably. It is true that even clean surfaces are covered by films of condensed gases, probably monomolecular; for there is evidence that the valencies of the surface molecules are almost completely satisfied. These valencies, however, may be set free, as Beilby has shown, by polishing, or by increase of temperature. A crack, for example, in a sheet of glass cannot be caused to unite again by pressure alone, although the two surfaces must fit each other accurately.

The static friction between solid surfaces in contact, when seizure takes place, would appear to be akin to the shear which takes place, without fracture, in ductile solids. Here the atoms or molecules, in normal conditions, are adhering the one to the other, and if, owing to vibratory movements, the adhesion should be broken anywhere, the *same bond* is quickly restored, if the mass be only moderately strained. If, however, the mass should be in a state of considerable strain, broken bonds may make new attachments, and the solid be permanently deformed. In solids, such rearrangement of the bonds, under strain, takes place generally along definite planes which are visible under the microscope. In the case of liquids, although the majority of the molecules are bonded by chemical forces, a number are continually breaking bond, even in the absence of strain, but instead of again making the original bond they may form *fresh bonds* with other molecules. This theory was advanced by the present writer,[5] who remarked that: "Gravity may therefore give rise to a slow but continuous change of form in an elastic substance in the interior of which liquefaction and re-solidification are constantly going on." Langmuir,[6] who regards liquefaction and solidification as being chemical actions, has recently suggested the same idea. He remarks: "The mobility of a liquid is thus due to a shifting of the relative positions of atoms which are all chemically combined with each other."

Langmuir has shown that the molecules of adsorbed films on water are very regularly oriented, that portion which has the greater affinity for water uniting with the water molecules. But the other parts or ends of the adsorbed molecules have a greater attraction for each other than they have for the water, and they thus prevent the whole molecule from going into solution. Below such an adsorbed film the molecules of water must also be oriented in some regular manner, for it is reasonable to suppose that some portion of the water molecule has a greater attraction for the adsorbed film than other parts. Similar conditions, no doubt, hold in films adsorbed by solids, one end, or other portion of the molecule of the film, adhering to the solid, and the other forming the external surface. When two such adsorbed films on solid surfaces are brought into contact, it is the least chemically active ends of the molecules of

[1] See "The Theory of Lubrication," by W. B. Hardy, F.R.S., Fourth Report on Colloid Chemistry, page 185.

[2] "Memoires des Sçavans Etrangers," tome 163 and 333.
[3] Enc. Met., Light, page 447, 1830.
[4] "Proc.," Royal Institution, 1901.
[5] *Phil. Mag.*, February, 1888, p. 160.
[6] *Jour.*, Amer. Chem. Soc., Vol. XXXIX., September, 1917, page 1858.

the films which touch. Such an arrangement ensures that all the primary and secondary valencies are completely saturated, and also that there shall be the smallest stray field possible which could cause the two external film surfaces to adhere. There are thus produced films which adhere firmly to the solid surfaces, but are almost chemically inert as regards each other.

Lubricants thus act by covering metallic surfaces with thin layers of matter which have very little affinity for each other and will not readily seize. If seizing does take place, it is due to the rubbing off of the film, thus allowing the atoms or molecules of the solid metallic surfaces to adhere.

It does not seem possible to attribute the frictional resistance lubricating films offer to relative motion in any way to chemical affinity; for the static friction is proportional to the load, and increase of load only very slightly indeed varies the attractive power of chemical forces. Even in the case of clean glass faces, the attraction is so small that a weighted watch glass can be lifted off a glass plate by a force sensibly equal to its own weight, yet the watch glass will resist a pull of .85 or .95 of its own weight.

As properly lubricated surfaces under reasonable loads do not "seize," *i.e.*, bring chemical affinity into play, we must look to some other cause for an explanation of static friction. Amontons attributed the friction to asperities on the surfaces, and it may prove that the molecules themselves are the asperities to which friction is due. It is clear that the surface of an adsorbed film cannot be a perfectly smooth one. Most lubricants are organic substances, and the configuration of their atoms is very different from that of metallic solids. In metallic surfaces we have generally single separate atoms. In organic lubricants the atoms are combined to form complex molecules, which are usually atomic chains. The chemically active atoms are situated at certain points of these chains—it may be at one end, or between the ends, or at both places. The atoms at the other end and parts of the chain have very weak fields of force, because their major attractive forces have become neutralised in the formation of the molecule. Perhaps a lubricated metallic surface may be most satisfactorily likened to a surface of velvet pile, the hydro-carbon chains representing the nap.

Static friction varies not only with the lubricant, but also with the nature of the surface upon which it rests. This may be due to the fact that one molecule, or a number of molecules, may attach themselves to each atom or molecule of the surface, or, as the volumes occupied by the molecules are greater than the atomic volumes of pure metals, several metallic atoms may attract one molecule of the lubricant. The density of the "pile" must thus vary with the metallic element to which it adheres.

In the case of hydrocarbon oils, we must regard the ends of the chains of the molecules forming the adsorbed films as the asperities which give rise to friction. They are, no doubt, elastic, and have to be forced over or between each other's ends to allow of motion taking place. They accomplish this by compressing and bending each other as they move relatively, each chain end slipping back into position as it is released, and its potential energy is converted into heat. As the displacement of the chains is purely elastic, the resistance is proportional to the average load on the temporarily displaced asperities. The action is thus a purely mechanical one, the dependence of the friction on load being of the same nature with the asperities of molecular dimensions in adsorbed films as with the very coarse asperities on rough boards or other surfaces. The actual value of the coefficient of friction, however, depends upon the form and stiffness of the asperities in each instance. When actual sliding takes place abrasion often results, and particles are torn out which act as ball bearings, more or less, and convert part of the friction into rolling friction. It thus often results that the coefficient of friction varies with changes of speed and time of rubbing.

Hardy and Doubleday's experiments[7] show that the curves connecting static friction with molecular weight cut the base line; that is to say, above a molecular weight which is different for each chemical series, static friction should vanish.[8] Very careful experiments showed that, with certain substances of such large molecular weight that theoretically, according to Hardy, the friction should have disappeared, with the smallest tractive forces he could apply the slider slowly moved, the observed rate being of the order of 0.4 mm. per hour. However, a movement of this nature need not be peculiar to substances whose molecular weights are so large that their "theoretical" static frictions should be nil. It may be a condition of shear, *similar* to viscous flow, resulting from vibration of the ends of the hydrocarbon chains. Such chains must be vibrating more or less violently, like the cilia covering certain living organs. The amplitude of the vibration of short chains would be small, and they would not change their relative positions unless the strain due to the tangential force were large. With long chains, on the other hand, the amplitude would be large, and small forces tangentially applied would result in slow slip. To produce moderately rapid slip—about 1ft. per minute—considerable force is required, and it is this force whose amount should be regarded as giving the practically useful static friction; for such low speed friction and static friction are practically identical.

[7] "Boundary Lubrication." W. B. Hardy and Miss I. Doubleday. "Proc.," Roy. Soc., Vol. 100 (1922), page 571.
[8] "Proc.," Roy. Soc., Vol. 101 (1922), page 492.

A New Type of Excavator.

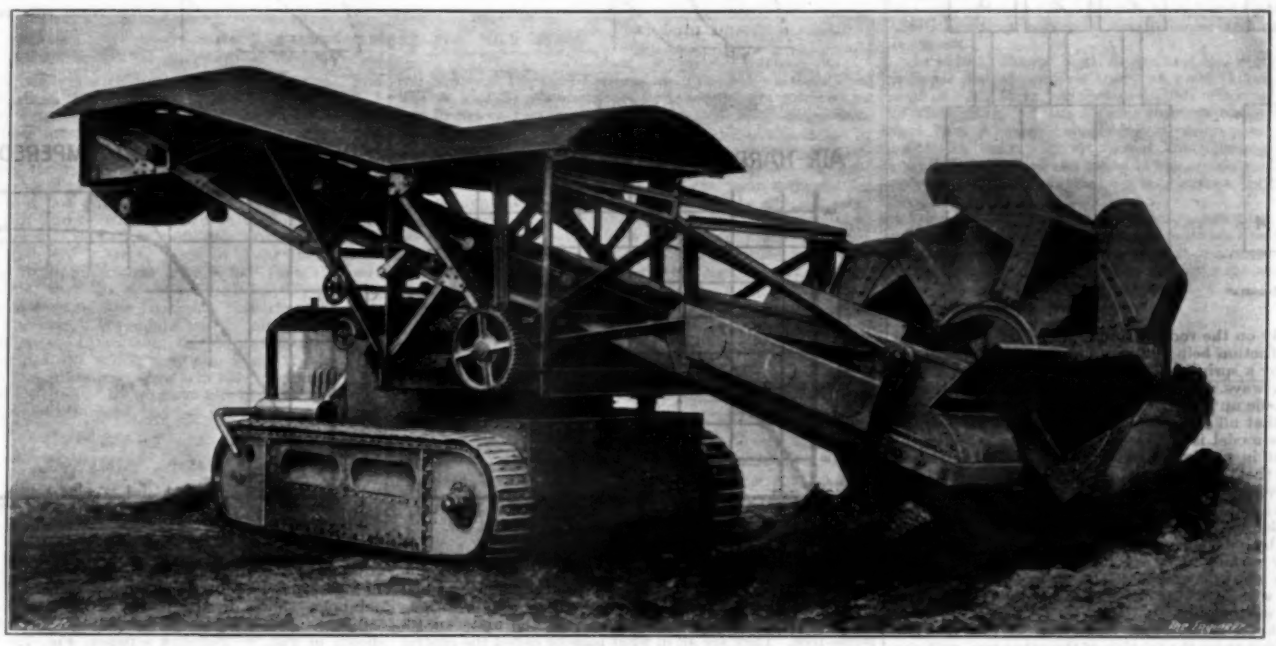
A NEW machine for carrying out excavation work and for handling such materials as coal, ores, phosphates, slag, clinker, &c., has recently been placed upon the market by the Wellman Smith Owen Engineering Corporation, Limited. It is known as the "Clere" patented mechanical rotary excavator, and one form of it is illustrated in the accompanying engraving. The leading characteristic claimed for this machine is its continuous operation. The cutting tool, which, as will be seen, has the form of a wheel, does not leave its working face to transport the material backwards, the transportation being effected by a belt conveyor, and it is pointed out that there is no interruption to the cutting or gathering, nor is there any interruption to the delivery into the truck to be loaded; and that, by having a continuous stream of material passing along the conveyor into trucks, each truck can be absolutely filled, whereas in loading wagons by means of a shovel or grab it frequently happens that the conveyance will not take another full grab and so has to go away only partially filled.

The machine is built on lines similar to those of revolving cranes and is composed of an undercarriage supporting the superstructure, which consists of two main parts, namely, the excavator and belt conveyor. The whole of the superstructure revolves completely, and the excavating portion can be lifted or lowered, thus enabling the rotary shovel to operate at an angle above or below the ground level on which the track rests. A single motor serves to drive four motions, *i.e.*, travelling, slewing of the upper portion, rotation of the excavating wheel, and running the conveyor. The rotary shovel is, however, raised or lowered by hand.

The excavating wheel delivers on to the belt as well as acting as an excavator. Instead of throwing its load over the back of the wheel, it discharges it to one side and at the centre in successive lots, but gradually as the wheel turns over; and it is asserted that it feeds any conveyor belt just as does an automatic conveyor feeder and provides an almost constant load on the belt. The cutting edges of the buckets on the wheel are especially curved to enable the material to be taken up in whatever position the machine may be working, and the buckets are designed with a view to ensuring that the material shall slide continuously towards the evacuation channel and shall never any time remain in equilibrium in the buckets. This motion, combined with the rotation of the complete set of buckets, causes the evacuation of the material towards the external face of the wheel. The ejection commences when the bucket arrives a little above the axis of rotation, and is completed before the pouring edge of each bucket has passed the edge of the chute through which the material is fed to the conveyor.

When required to operate on very hard ground, the attacking edges can be fitted with teeth, the shape of which may be varied according to the conditions under which the machine is working, and it is alleged that the wear due to friction on a machine of this type is very small indeed in comparison with that experienced with the dredger type, in which the buckets are connected one to another by links and trunnions.

The principal dimensions of the excavator, *i.e.*, the diameter and width of the excavating wheel, are determined according to the output required, and the capacity of the machine can be regulated to range from 15 to 500 cubic yards per hour with excavating wheels measuring from 6ft. to 18ft. in diameter. The revolving motion of the superstructure enables the rotary shovel to operate at any angle, and in order further to facilitate its operation and also to obviate the trouble of shifting the track, the machine, which may be driven by a paraffin or petrol motor, may be mounted on caterpillar tracks, as shown in our illustration. A heavier and more elaborate form of the machine is mounted on a portal structure not unlike that of dock cranes. In this form it is designed for a large output and for continuous working in connection with mines, excavating for canals, levelling for railways, extraction of lignite and the general handling of ores, &c. Such a machine is said to be capable of loading 500 cubic yards per hour. It is provided with an excavating wheel of 16ft. diameter, attached to a movable arm 46ft. in length, which is hinged on a small carriage, allowing a progressive motion of 6ft. towards the pile. The arm may be raised to a height of 40ft. above ground level and is capable of a complete revolution, allowing operation on a semi-circular front of 125ft. diameter. In still another form the machine is mounted on a wheeled bogie designed to run on a standard-gauge line, and is intended for filling trucks or wagons running on parallel lines from a pile alongside the line on which it runs itself, or for excavating a bank alongside which its line is laid.



THE "CLERE" MECHANICAL ROTARY EXCAVATOR

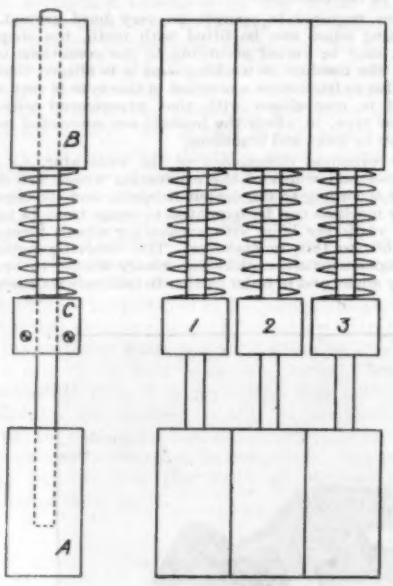
REUTER'S Trade Service learns that the Lithuanian Ministry of Communications is projecting a railway between Kretinga and Palanga, on the Baltic coast. It has requested the Government to grant permission for preliminary work this year, so that if it should appear that there are no great difficulties in the way of construction, the work can be actually begun in the spring of 1923. There is, it is said, a sufficiency of building material for the purpose. A French financial group has applied for permission to build a railway from Memel to Radzivilishki, to improve the Memel harbour, regulate the Niemen and exploit the bends of the river for purposes of electrification.

Fatigue in Metals.*

By C. F. JENKIN.

ABOUT a year ago I was asked to read this paper. About six months ago I wrote a paper, knowing that I should be very busy this autumn, and made a model to illustrate a small point in it. But as I played with the model to learn how to use it, it grew too strong for me and took command, and for the last six months I have been its obedient slave—for the model explained the whole of my subject—Fatigue. The model destroyed my first paper, and I have been obliged to write a new one in haste, putting it off from day to day as the model taught me new things. The written paper has suffered, but I hope you will find my account of the model more interesting than the tentative theories which filled the old paper. But in any case, I can speak of nothing else.

A simple form of model is shown in Fig. 1. It is made up of three or more "units" fastened together top and bottom. The units are all similar. Each is made up of three pieces—a block A with a rod fixed in it, a block B



"THE ENGINEER" FIG. 1. SWAN SC.

sliding freely on the rod, and a block C sliding on the rod stiffly, the friction being adjustable. Blocks B and C are connected by a spring. The model may be constructed in many other ways. The only requirements are (1) that it shall be elastic up to a point and then slip with solid friction; (2) that all the units shall not slip at once as the load on the model is increased. This latter requirement may be met in two ways—either by making the friction different in the different units, or by making the springs of different strengths. The former method is the simplest, and is used in all the models I shall speak of to-day.

The model may be adjusted so as to have different properties by varying the friction in the different units and also by pushing up or pulling down some of the blocks C, so as to give the units initial compression or tension. The model will set itself so that the compression and tension forces will balance.

Let us choose a three-unit model for the first test and give No. 2 unit twice the friction of the other two, and give No. 1 unit a small tension, and No. 3 unit an equal compression, so that the model will still be in equilibrium. Let us imagine that the model is put in a static testing machine with an extensometer attached and tested in tension. To show what will happen, I will extend the model by hand. At first it stretches elastically, then No. 1 slips, and later No. 3 slips, and finally No. 2 slips. No larger force can be applied. The load/extension diagram given by the extensometer would have the form shown in Fig. 2. This figure is easily constructed. The three lines at 45 deg. are the load/extension lines for the three equal springs. They slope up to the points at which they slip and then are horizontal. The graph for the whole model is found by adding the co-ordinates of all three. If the model were made up of more units, the graph would be less angular. P is the limit of proportionality (elastic limit), Y.P. is the yield point, F.L. is the fatigue limit. How this is found I shall explain later. Now compare this with Fig. 3, which is a load/strain graph for hardened, but untempered, 100-ton steel.

Next, let us set the model differently. Give No. 2 unit a certain tension and Nos. 1 and 3 a compression of half that amount. The load/strain graph is shown in Fig. 4. Compare this with Fig. 5, which is the load/strain graph for a well-tempered steel.

Next, let us take a model of ten units, and give eight of the units nearly equal friction and the remaining two slightly less. As I pull this model, the weakest unit slips first, then the next. As each slips, more load is thrown on the rest, and when the first of the eight nearly equal units slips, the extra load will cause the next to slip at once, and they will all slip—Jack-run-for-mustard. The graph for this model is shown in Fig. 6. Compare this with Dalby's photographic record for mild steel—Fig. 7.

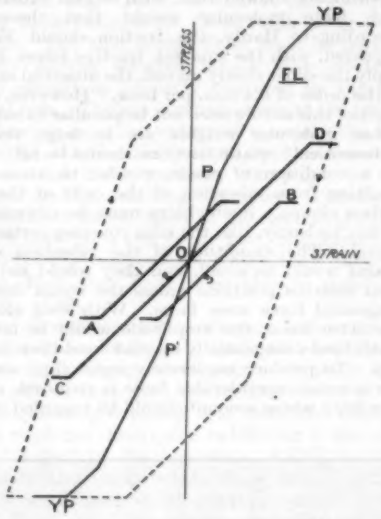
In this explanation I have assumed that when the unit slips it becomes weaker, and so throws more load on the rest. I return to this point later.

But there is another very pretty point to notice. Watch the model closely. The units tend to move in little jerks, not quite smoothly, owing to the difference between the static friction and the sliding friction. These little jerks appear in Dalby's photograph of the steel.

* Paper read before the Royal Aeronautical Society on December 7th.

If we compress Model No. 2, we shall get the lower curve in Fig. 4. Note that the elastic limits are different in compression and tension. If we carry the test on these models round a cycle we shall get the hysteresis loops shown in Figs. 2 and 4. These have the typical shape of metal hysteresis loops, curved rising lines and straight falling lines. The model will thus represent any of the typical steels very closely—up to the yield point. I have not made it go higher for reasons I shall explain later.

Now let us see what it does when tested under alternating loads. To start with, apply a large alternating strain to the three-unit model. All the units slip backwards and forwards, but as the amplitude of the motion is reduced, first one, then another, and finally all the units cease slipping. The amplitude now is the largest which the



"THE ENGINEER" FIG. 2

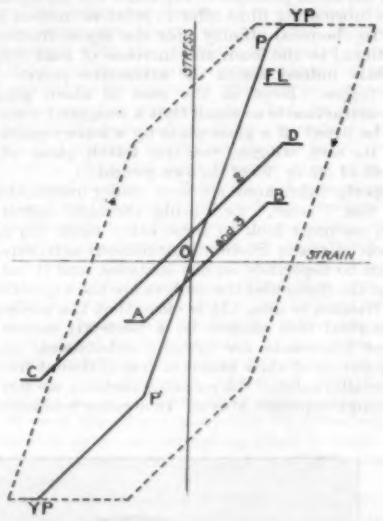


FIG. 4 SWAN SC.

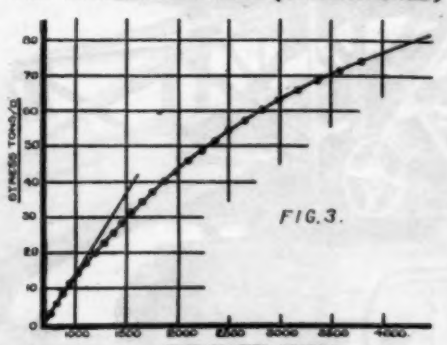


FIG. 3.

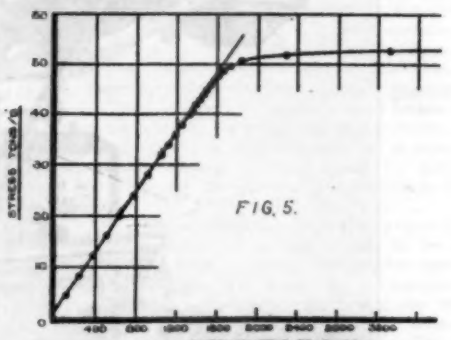


FIG. 5.

weakest unit will stand without slipping. The motion is elastic, and, as Bauschinger first stated, the metal will stand this motion indefinitely. We have found the fatigue limit. When the model comes to rest, the units are all stress-free. They are all in what may be called the central position. The fatigue limit points in Figs. 2 and 4 were found in this way.

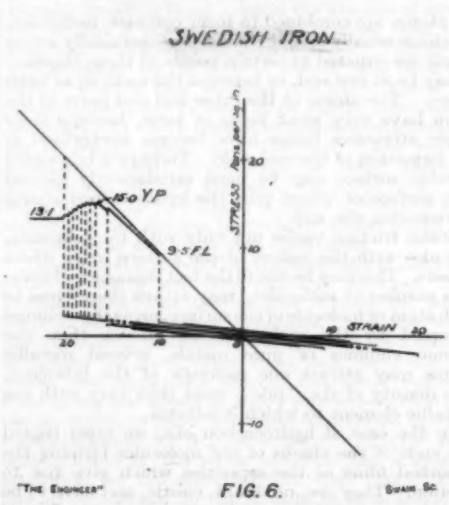
The truth of Bauschinger's theorem—the identity of elastic range and fatigue range—has been confirmed by Bairstow (Phil. Trans. Roy. Soc., Vol. 210); also by Gough (THE ENGINEER, August 12th, 1921). Gough invented a test which has turned out to be of the greatest value. A mirror is fixed on the end of the Wöhler test piece and adjusted to run truly in a plane perpendicular to the axis of rotation. The spot of light is reflected by this mirror on to a scale, and as the specimen is loaded this spot moves down the scale. If the deflections are plotted against the load, the graph is a straight line as long as the metal is elastic. Thus the limit of proportionality in Gough's rotating test indicates the fatigue limit. The accuracy of this test has been repeatedly confirmed both by Gough and Lea for many metals. This test gives a method of finding the fatigue limit in a few minutes on a single test piece.

Let Gough's test be applied to a copper test piece. Under static test, copper is not elastic for even the smallest load. The stress-strain curve bends off from the origin without any straight portion. The model representing copper has the maximum possible initial stresses in the units, so that one begins to slip the moment any load is applied. Applying the alternating load to the model, the units will slip into central positions, and we shall find a fatigue range as before. But this test will leave the units in a stress-free condition, and we ought therefore after the test to find the copper elastic. This remarkable result was found experimentally by Gough, and at my suggestion he repeated the test, raising the range gradually first to one-quarter, then to one-half, then to three-quarters of the full range. In this way, the elastic limit of the copper was found to be raised first to one-quarter, then one-half, then to three-quarters of the full range. Thus the experiment exactly confirmed the prophecy based on the model.

The same experiment is now being tried on hardened 100-ton steel. The stress-strain curve—Fig. 3—we have already seen bends off almost from the origin. By applying an alternating stress the steel should be made elastic up to the fatigue limit, according to my theory.

The fatigue limit we have found is for equal tension and compression loads, but there are infinite series of fatigue limits for unequal loads. How can their magnitudes be found? Suppose that an alternating stress were applied to the model unsymmetrically, so that the tension were greater than the compression. This might be increased till the weakest unit began to slip backwards and forwards. When that occurred we should have reached the fatigue limits for these particular unequal loads, and the range is the same as before. We may go on making such tests, making the motion more and more unsymmetrical, and the range will remain the same till a new limiting condition intervenes, viz., that the maximum tensile stress must not exceed the ultimate strength of the test piece. This condition reduces the range of stress which can be applied. The graph representing the range of stress plotted against the inferior stress will therefore consist of two straight lines—one horizontal at the range for the weakest unit and the other at 45 deg. through the ultimate strength—see Fig. 8. This graph, according to the text-books, should be Gerber's parabola—shown in the figure. The model appears to fail here. But compare the graph with the actual results shown in Fig. 9—Bairstow's paper, Fig. 7. The model is clearly right and Gerber wrong.

Before considering further properties of the model, let us see whether there is anything in the metal which can



"THE ENGINEER" FIG. 6. SWAN SC.

behave as the units in the model behave. The crystals are obviously the units. Ewing and Rosenhain* have shown that they are elastic up to a point and then slip along slip planes. They also pointed out that the slip planes lie at all angles with the line of action of the load, so that the resolved shearing stresses along the planes will have all values from a maximum in planes at 45 deg. to zero in planes perpendicular to the load. Thus the crystals will not all slip at once, but one after another. Thus we see that the known pro-

* Phil. Trans. Roy. Soc., Vol. 193A.

perties of the crystals exactly correspond with the assumed properties of the model. Finally, Ewing and Humfrey† showed that when slipping backwards and forwards takes place the slipping surfaces wear, and a crack is ultimately formed, which grows till final fatigue failure occurs. Thus our criterion for the fatigue limit is correct, viz., that we must have no slipping even in the weakest unit.

But if the model represents the metal so accurately, why does it cease to do so at the yield point? The ultimate strength of a metal is much higher, but the ultimate strength of the model is the same as the yield point. It would not be difficult to alter the model to make it imitate the real metal, but the additions necessary for this purpose would not correspond with any reality in the metal. The rise of strength in the metal above the yield point is, I believe, due to the mutual interferences between the crystals. These must have a great effect as soon as there is much distortion—that is, after the yield point. The model and my theory are therefore limited to stresses not exceeding the yield point.

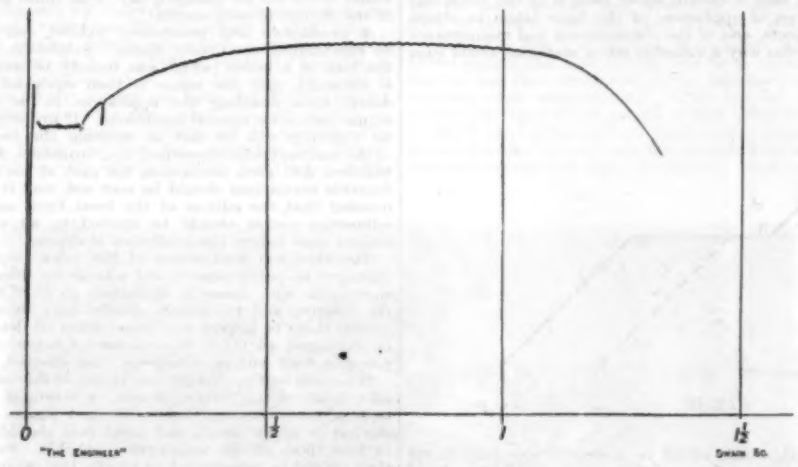


FIG. 7—DALBY'S RECORD FOR MILD STEEL

But fatigue is not quite so simple as this. Think of a crystal shearing and then of the two parts slipping backwards and forwards on each other. We should expect to find that it required a larger force to shear the crystal than to keep it slipping when once it had been sheared. In other words, that the adhesion between the surfaces would be greater than the friction. Experiments show that this is the case. The model can be altered so as to show this difference by making the sliding blocks grip a collar on the rod, off which they slip when the force is greater than the adhesion. How will this modification of the model affect the results we have already got? I have not time to prove it to-night, but you will find that nothing we have so far found is essentially altered till we come to the graph of the complete series of fatigue ranges. Fig. 10 shows the range graph for a five-unit model arranged to represent axle steel allowing for the effect of adhesion. Instead of being horizontal at the top, it rises by steps, but these steps may be smoothed out by using more units in the model. Compare this with Bairstow's graph for axle steel—Fig. 9. You will see how closely they agree.

SWEDISH IRON

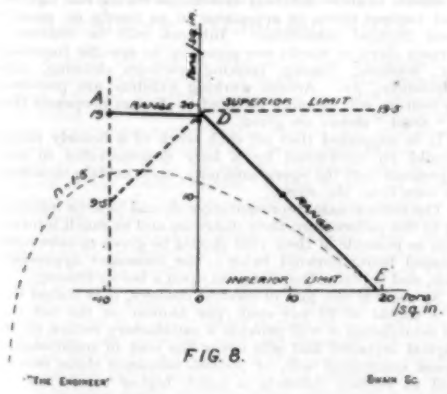


FIG. 8.

This graph suggested two remarkable experiments. If all the adhesions could be broken down, then the fatigue limit should fall to the value 19.5. This can be done by bringing the metal into the "cyclic condition" by overloading it under alternating stress and then gradually reducing the load. All the adhesions are broken down by this treatment, and the crystals are left in the stress-free condition, as we have seen. Tested in this condition, axle steel should have a fatigue limit 25 per cent. lower than in the normal condition. I tried this experiment on some 0.33 carbon steel. The fatigue limit was lowered 29 per cent.

The second experiment was even more remarkable. If the steel could be made stress-free, and then have its adhesion restored, the fatigue limit should be raised to the full adhesion value—some 20 or 30 per cent. above the ordinary value. I took the sample which I have just described, which was in the stress-free condition, and boiled it in water for two hours. This caused the crystals to heal, and so restored their adhesion. I then tested it, and the fatigue limit was 21 per cent. above the original value. These remarkable experiments show that the fatigue limit of steel can have any value between two limits. They are shown in Fig. 11. Finally, these experiments give a direct measure of the ratio adhesion/friction, which for the steel tested was 1.7.

Other methods may be employed for raising the fatigue limit. If the metal is very slightly overloaded in the Wöhler test for a few seconds and the load then reduced again, the adhesion of some of the crystals is broken down, but so little damage is done that the sheared faces heal at once and the process can be repeated again and again, each time raising the maximum load a little. Gough, at the National Physical Laboratory, raised the fatigue limit in this way 20 per cent. for the steel already referred to, and Professor Lea in Birmingham raised another specimen by rather more.

These experiments show that healing of sheared crystals occurs and that this action may be hastened by very moderate temperatures. Also that the time required for healing depends on the extent to which the slipping faces have been damaged by rubbing. We are thus introduced to a new idea—healing may be taking place during a fatigue test, and the ultimate result (fracture or safety) may depend on a sort of race between slipping and healing.

Healing may be thought of as the recrystallisation of the minute quantity of metal disarranged by slipping, and it is not difficult to see why this takes place easily and quickly when we remember that the surfaces between which it occurs are parallel arrangements of crystallised material.

If healing produces an appreciable effect, it will raise the fatigue range above the elastic range, and the amount it raises the fatigue range will be greater the more time there is for the action to take place, *i.e.*, the slower the alternations of stress. A second modification of the fatigue range may occur, due to the fact, first demonstrated by Hopkinson, that it takes time for the crystals to slip. Hopkinson showed that for a very short duration of stress, say, one-thousandth of a second, metals were elastic far above their ordinary limit. This phenomenon should also raise the fatigue range above the elastic range, but will be most effective at high speeds. These two actions make it necessary to qualify Bauschinger's general statement on the equality of the elastic range and the fatigue range. The magnitude of the two effects is being investigated. It seems probable that healing may be very effective at the temperatures at which some parts of engines—for example, valve springs—work.

The events occurring in the metal undergoing a fatigue test may be examined in other ways. If there is friction between the parts of crystals there must be heat generated, and we can measure this heat by observing the rise of temperature of the metal. This was first done by Hopkinson, and many observers have used the method since. The temperature rise follows closely on the departure from elasticity, *i.e.*, it becomes large when the crystals start slipping. But there is found to be a very small evolution of heat at stresses far below the fatigue limit, and that the heat gradually increases as the load is increased. In other words, there is a small elastic hysteresis. The model does not indicate this elastic hysteresis, and what it is due to is not yet known.

Temperature observations have brought to light some very striking phenomena. When nickel is tested, there occur sudden heat bursts which rapidly disappear again. They recur every time the load is raised. How can these temporary evolutions of heat be explained? Consider the model. If it were stretched and compressed 2000 times a minute without lubrication, what would happen? The sliding block would "run hot and seize." While it slipped heat would be generated, but the moment it seized the generation of heat would cease. That this may be a true explanation of what happens in nickel is confirmed by two striking facts. If the heat is due to slipping, heat bursts cannot begin below the elastic limit, for this is the point at which the first crystal slips. Experiment shows that they do not. Again, if a sample is tested up to fairly high stresses and all the crystals which slipped have seized, then if the test is repeated on the same sample no heat bursts can occur. This remarkable result is also confirmed by experiment. The trouble is like an infantile illness—a rapid rise of temperature, which a day or two later subsides, and immunity from the illness follows for the rest of one's life. Similar heat bursts occur in hard steel, but they last very much longer and are less pronounced.

In 1915 Professor F. H. Smith and Mr. Wedgwood published a paper‡ on what they call yield ranges, illustrated with a very large number of figures showing the results of their tests. I have gone through those figures and find that a model consisting of only three units will reproduce them all. Of course, the figures given by the model are very angular since it has so few units, but that defect could be remedied to any extent by multiplying the number of units.

I am not sure if I have made it clear that the model will give quantitative results as well as qualitative. It is quite easy to construct a model to represent any given metal to scale. To show how accurate the results are, I will give one more illustration. Professor Smith summarised a large number of his results in a single figure giving yield ranges plotted against mean stress. I designed a model of three units to represent the same steel, and constructed to scale the corresponding graph. Fig. 12 shows the graph of the yield ranges, which is very similar to that for the fatigue ranges. On it is plotted the superior stress and the mean stress. Below it, the superior and inferior stresses are plotted on a mean stress base; the figure is a skew polygon. On this, to the same scale, I have drawn Smith's figure representing his test results. The agreement is, I think, striking. If the model could speak it would say: "I could have foretold the whole of the results of the tests which have taken you years to make."

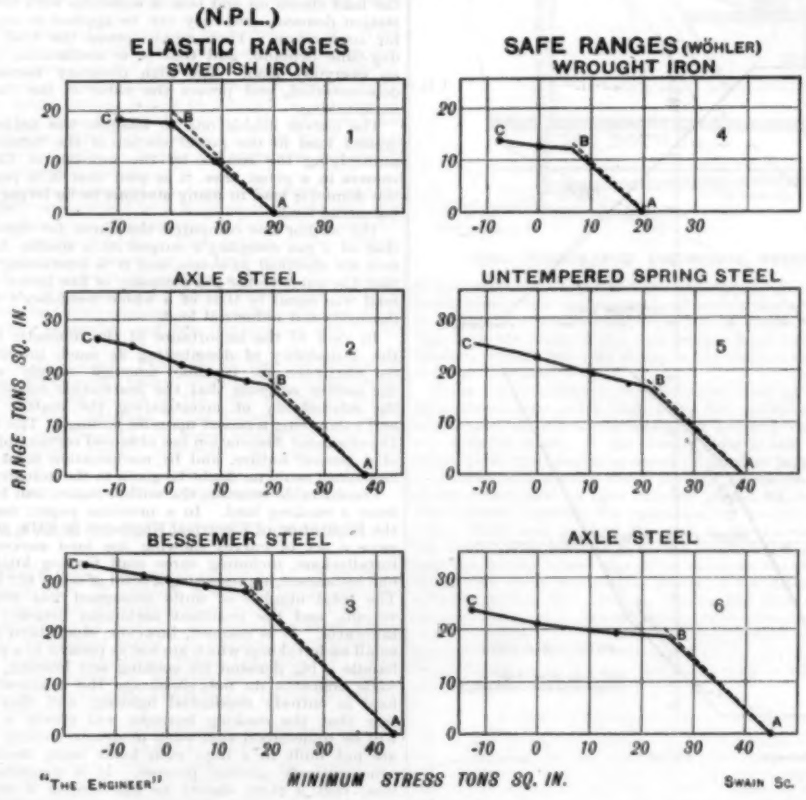


FIG. 9

† Phil. Trans. Roy. Soc., Vol. 200, p. 248.

‡ Journal of the Iron and Steel Institute, Vol. XCI.

The theory I have outlined applies to iron, steel, nickel and copper. Whether it is true for all metals is not yet known. It is not unlikely that brittle materials like cast iron may behave differently. It ought to apply to fatigue in shear as well as in tension, but whether it does has not yet been ascertained.

Perhaps you wish to know the practical end of all these researches, and may feel inclined to say: "What is the use of your pretty models and fine theories?"

We hope before long to be able to put figures into designers' hands which will be a sure basis for all their strength calculations, figures which will not need factors of safety to allow for our ignorance of the strength of the materials. We hope to introduce fatigue limits into steel specifications, so that you will buy your materials on the basis of their useful strengths. We hope to have methods of fatigue testing as simple as tensile tests. We hope to be able to issue instructions which will save endless failures of engines. All these things are already possible. We have now only to verify and confirm before issuing our reports.

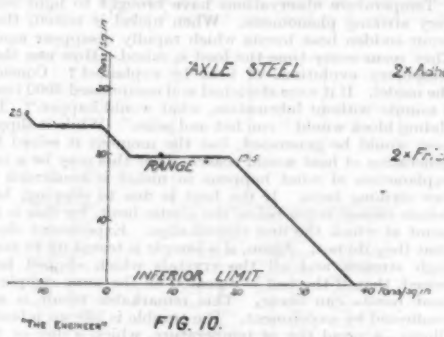


FIG. 10.

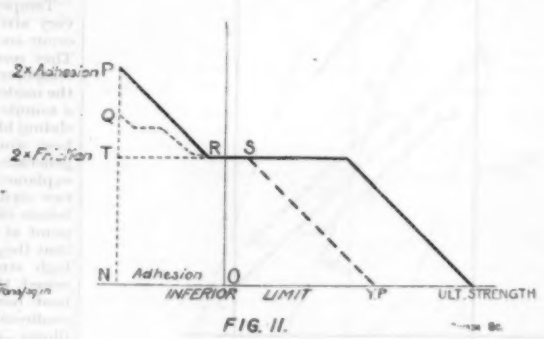


FIG. 11.

I will venture to make one suggestion to-day to all engine builders. Never run a new engine on a full-power test till you have raised the fatigue limits of all the highly stressed parts. This can be done, as Gough and Lea have shown, for test pieces by making a series of short runs at gradually increasing loads, finishing up at the highest overload which the engine will ever be called on to exert and slowing down between each. No marine engineer ever starts up a ship's engine at full load. He coaxes it up gradually. This may be partly to give the bearings time to run in; but the experiments I have described suggest that it may also be most valuable in giving time for the steel to "slip into the central position" and to heal. A proper start may add 20 per cent. to the engine's strength. We shall soon know the best way to make this gradual start. This suggestion is still partly guesswork, but it is the sort of practical result we hope to achieve very soon.

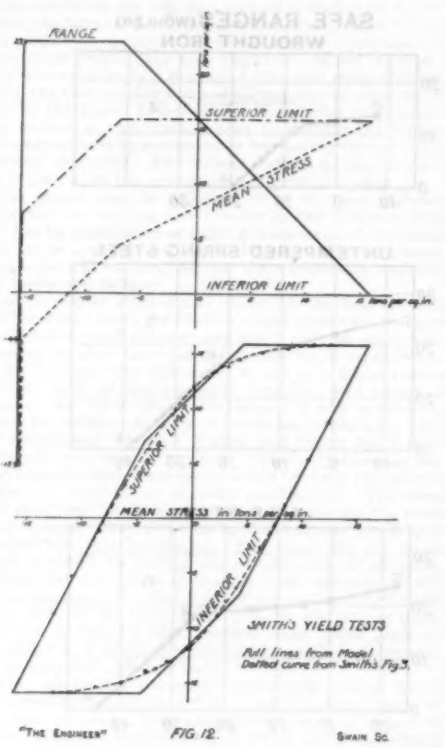


FIG. 12.

In conclusion, I wish to express my very great obligations to the Aeronautical Research Committee. The Fatigue Panel of that Committee, of which I have the honour to be a member, has been working on this subject since its formation, and all the members of it have been indefatigable in their endeavour to throw light on this most puzzling subject. Researches have been going on at the National Physical Laboratory, Royal Aircraft Establishment, Royal Naval College, and the Universities of Oxford, Birmingham, Liverpool, Manchester and Edinburgh, financed by the Board of Scientific and Industrial Research on the recommendation of the Aeronautical Research Committee. This work is proceeding, and is now advancing rapidly. I have been keenly interested in it since I had to deal with fatigue failures during the war, and I feel sure that the Aeronautical Research Committee is performing a most valuable service to aeronautics by enabling these researches to be carried out.

Domestic Load Building.

SOME useful suggestions concerning the methods which central station engines should adopt for the building up of domestic loads was given in a paper read before the Institution of Electrical Engineers on November 30th by Mr. W. A. Gillott. Every individual, from the chief engineer to the sales representative, should, the author urged, possess an adequate knowledge of domestic electrification before attempting to advise others, and every member of the staff should have an electrical installation in his home to enable them to gain the requisite knowledge and appreciation of electrical methods. It is desirable, it is considered, to keep a careful set of records of the behaviour of each type of appliance, of the time taken to attain certain objects, and of the consumption and maintenance costs. In this way a valuable set of statistics would soon be collected, which would be a considerable help in the direction of establishing a foundation upon which to build a suitable scheme. During these observations a complete set of recording ammeter charts should be secured.

Curves given in the paper indicate the nature of the load upon the Billingham housing estate, and show the demand of twenty-five houses, or approximately one-third of the whole voltage. Each house contains a cooker, a washing boiler with a capacity of 10 gallons, an electric fire, and a kettle or electric iron. All the houses are also electrically illuminated. The average number of kilowatts of equipment installed in each house is 11.28, and the total connected load is therefore $11.28 \times 25 = 282$ kilowatts, the pressure at the consumers' terminals being 250 volts. These curves give much information, and the engineer is able to estimate with accuracy the size of feeder cables necessary for a district. They show at a glance how the load comes on and how it coincides with the general station demand, and they can be applied to any system for comparison. They amply prove the load to be a day-time demand, and that it is continuous, *i.e.*, it is an everyday load. The high diversity factor is well demonstrated, and proves the value of the load to an undertaking.

The curves enable one to imagine the nature of the system load in the power station of the future, for by multiplying the results by the number of likely consumers in a given area, it is seen that it is possible for the domestic load in many stations to be larger than the industrial load.

The author has compared the curve for Sunday with that of a gas company's output on a similar day. The two are identical in shape, and it is interesting to relate that the value to the gas company of five hours' Sunday's load was equal to that of a whole week-day's combined domestic and industrial load.

In view of the importance of the domestic load, and the desirability of distributing as much information of its character as possible amongst supply engineers, the author suggests that the Institution might consider the advisability of investigating the matter in detail and submitting a report upon its findings. The Electrical Development Association has obtained certain information of a general nature, and by co-operation most valuable assistance could no doubt be given to the industry.

Considerable revenue, the author states, can be secured from a cooking load. In a previous paper, read before the Institution of Electrical Engineers in 1918, the author gave a set of curves showing the load curves of four installations, including three staff feeding kitchens and one restaurant, representing a total of some 452 kilowatts. The total number of units consumed was 290,000 per annum, and the resultant maximum demand was 190 kilowatts. It is realised, however, that there are many small undertakings which are not at present in a position to handle a big demand for cooking and heating, and that some concerns do not encourage the business as their load is entirely residential lighting, and they possibly fear that the cooking business will create a loss. It will be understood that even moderate cooking demands are not built in a day, such loads being secured by a comparatively gradual process. It is suggested, therefore, that a start should be made upon a small scale in order to gain experience in districts where the plant and cable capacity are small and the rate is unsuitable for complete cookers. It will be found that if auxiliary appliances, *e.g.*, kettles, irons, toasters, boiling plates, washing machines, vacuum cleaners, &c., are used, their existence will have a greater effect on the financial returns than on the station maximum demand. The author is of opinion that if men were to study the internal domestic problem more closely or were called upon to do the actual work, the use of electrical labour-saving devices would be greatly increased.

In dealing with the propaganda side of the subject, the author refers to the possibilities of the local Press, mailing letters, and leaflets, posters, exhibitions, showrooms, local calls, lantern slides, &c. As an illustration, the author takes a town with a population of, say, 100,000, in which the sum of £500 is to be allowed for one year's advertising, it also being decided to adopt a hiring policy for electrical appliances, and to reduce the price of electricity. It is suggested that a staff conference should be held, at which the programme could be discussed to ensure that the campaign should be commenced with at least the majority of the members enthusiastic and co-operating to reach some definite goal, say, 250, 500, or 1000 kilowatts connected in a specified period. In the early stages it will probably be found advisable to adopt the least line of resistance by encouraging the existing consumers to increase their demand, and there are other obvious reasons for this procedure.

Municipal undertakings owning tramways, the author goes on to explain, have the advantage in being in a position to exhibit showcards or notices in the tramcars at possibly no expense beyond the printing. Lantern slides can be exhibited at the local cinema houses or theatres each week throughout the year. Those slides would doubtless be changed, say, four times per annum at the change of each season.

A productive and economical exhibit can be given by establishing a "Comfy Home" exhibition. For this the loan of a house (which can usually be secured free) is obtained, and the house is then equipped in every detail, thus enabling the appliances to be shown in actual use under normal conditions. If properly handled no difficulty will be met in securing the co-operation of the various trades concerned, *i.e.*, furnishers, decorators, builders, &c., each performing his part at his own cost. Suitable invitations should be sent out, and it is recommended that the editors of the local Press and certain influential people should be invited to an electrically cooked meal before the exhibition is opened.

The electrical contractors of the town could be encouraged to participate in the scheme by dressing their showrooms with domestic appliances so as to fit in with the scheme, and the clients should have every facility offered them to inspect the home, when all details would be explained to them, the contractor being, of course, properly dealt with regarding any sales effected.

It cannot be too strongly urged, the author states, that an exhibit of this nature should be arranged to appeal especially to women; their needs and desires should be studied in every detail, and great care should be taken to give them all the information possible. In addition, they should be encouraged to handle the various devices for domestic use.

It may be found desirable to arrange for private demonstrations on selected days, for the benefit of those who would not care to discuss matters when other visitors were within hearing distance. This will ensure more rapid progress being made. It is advisable at the outset to secure the interest of women, for they will then make it their business to persuade their husbands to complete the transaction.

It would be helpful, the author considers, if an electrical exhibition could be held at which manufacturers and contractors would co-operate. Endeavour should be made, the author explains, to show all classes of electrical operations that are of the greatest interest to the inhabitants. Arrangements might be made to establish a series of self-contained exhibits, such as a model kitchen with cooker, water heater, clothes washer, &c., in operation, a shoe-repairing shop, with the stitching machine and sole-polishing iron electrically operated, a confectioner's bench, with cakes and chocolates made electrically, a small electric laundry, and a day and night nursery complete with all requisites from those for rocking the cradle and warming the milk to an electric sewing machine for making babies' clothes.

The use of showrooms to an electric supply undertaking is more appreciated at the present time, but it is essential that, to ensure success, they should be properly managed. If there is sufficient space to do so it will be desirable to show different systems of wiring and lighting, and various types of apparatus in as nearly as possible their normal conditions. Interest will be created if certain days or weeks are given up to specific functions, *e.g.*, washing, ironing, cooking, vacuum cleaning, table appliances, &c. Actual working exhibits are preferred, as visitors will be more inclined to discuss proposals than if "dead" shows are given.

It is suggested that all such work of a homely nature should be conducted by a lady demonstrator in such a position that the operations may, upon certain occasions, be seen from the street.

The outside sales representative should be kept informed as to the callers from their districts, and as much information as possible of their visit should be given to save much ground being covered twice; the consumer appreciates this, and it places the salesman upon a better footing.

As regards the hire of electric cookers, it is stated that if a rental of 20 per cent. per annum on the net cost be established it will provide a satisfactory return on the capital invested and will cover the cost of maintenance. Local conditions will, of course, influence these rentals, and in certain districts a much higher return can be obtained.

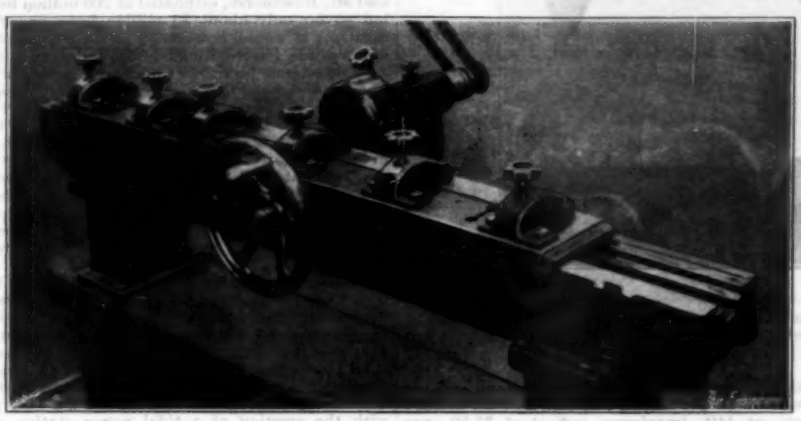
It must not, however, be overlooked that the mere fact of the cooker being installed and used earns a revenue which without such facility may not be obtained. Where the cooking load is not required so rapidly, as in places where the simple hire system is established, hire purchase, which does not involve as much capital outlay, and which will encourage the consumer to handle the appliances with greater care might be adopted. There are, of course, political conditions that prevent certain undertakings from supplying appliances in accordance with this scheme, but the formation of a company to conduct such work, as mentioned by Mr. C. H. Wordingham at the Sanitary Congress, would overcome the difficulty and enable a profitable business for all concerned to be established.

So satisfactory has been the progress in the erection of the Santiago electric station that completion is expected before the end of December. The work which has been carried out will enable the 110,000-volt current from the station at Maitenes to be received at the station, where the pressure will be transformed down to 550 volts and the current distributed for the lighting and street railway services of the Chilean capital, as well as for the service of the railway between Santiago and the port of Valparaiso, which is now being equipped for electric traction.

A Scraper-Knife Truing Machine.

SOME time ago a representative of Alfred Herbert, Ltd., Coventry, visited a large cocoa and chocolate works in Bristol, and noticed that on the grinding rolls a square-edged scraper-knife was used to keep the crushed cocoa from sticking to the rolls. The quality of the cocoa or chocolate largely depends on the uniform fineness to which the material is ground, and this fineness is adversely affected if the scraper-knife is not a close fit against the polished roll. As far as Messrs. Herbert know there has been no suitable machine available for truing up these scraper-knives until they designed the machine shown in the accompanying engraving. This machine has, we are informed, proved entirely satisfactory in every way.

There is another industry in which a similar scraper-knife or ductor, as it is called, is used—the intaglio or photogravure printing trade. In this case the knife is used to remove the surplus ink from the etched printing plate, and here again the knife must be a very close fit to the roller or the resulting picture will be spoiled. The new knife truing machine has, according to Messrs. Herbert, proved very satisfactory for this class of work,



SCRAPER-KNIFE TRUING MACHINE

the knives being finished true in a small fraction of the time previously required for the work.

The machine consists of a sliding table and a bed, which is traversed by hand by means of a rack and pinion. A face grinding wheel is mounted on a ball-bearing spindle in a bracket bolted to the bed. The wheel is fed to the work by means of a hand wheel and rack and pinion, with a fine adjustment screw stop to limit its travel. The work is laid on the table and held by the six dogs seen in the engraving. It is a very simple matter to set the knife against the small stops situated between the two end pairs of dogs, to clamp it, and to take a truing cut over its edge.

The Shipping, Engineering, and Machinery Exhibition, 1923.

A LUNCHEON was held on Wednesday last, by invitation of the Council of the Society of Motor Manufacturers and Traders, Limited, and the Committee of the 1923 Shipping, Engineering and Machinery Exhibition, to inaugurate the section embracing motor boats, marine and stationary internal combustion engines and accessories at the 1923 Exhibition, which is to be held at Olympia. At it, too, the work of the marine section of the Society of Motor Manufacturers and Traders, Limited, was explained.

Sir Charles Parsons spoke on the marine motor industry, and recalled the great progress which had been made since the early beginnings of the internal combustion engine in 1880. Lloyd's returns showed that in the period 1914 to 1922 the tonnage of motor ships had increased sixfold. The solution of large powers lay, he thought, along the lines of a series of multi-cylinder engines of, say, 500 brake horse-power per cylinder, such an arrangement giving increased flexibility, especially in the case of the electric drive—greater safety, lower weight and smaller first cost. The oil-burning steam turbine-driven steamship had also made great advances, and for the largest powers it had an assured place.

Vice-Admiral R. B. Dixon, Engineer-in-Chief of the Navy, said that since 1902, the year in which the Society of Motor Manufacturers and Traders, Limited, was founded, much had been done, but it was an interesting coincidence that it was in that year and on to 1908 that the Admiralty decided to replace steam-driven boats by motor boats, using oil fuel with a flash point of over 200 deg. Fah. In 1905 the two first motor boat engines were ordered. They were of the Diesel type, and had four cylinders developing 120 brake horse-power at 400 revolutions per minute, giving a speed of 10½ knots. Later, engines of 30 to 45 horse-power running at 700–950 revolutions were introduced, and the number of motor boat engines steadily increased until the steam-driven boat was entirely superseded. At the end of the war over 1500 motor boats were in service, and paraffin fuel having a flash point of from 84 deg. to 90 deg. Fah. was generally used. Since 1918, owing to the higher flash point of the oil available and its altered physical characteristics, vaporising difficulties have been met with, and all motor boat engines have since that time been designed for petrol. That, however, said Admiral Dixon, could not be considered a satisfactory solution in any sense. There was room for a cold-starting engine which would run on high flash point oil and at low speeds, and it was possible that the solution would be found in an engine of the Diesel type. Among the engines which came into the hands of the Admiralty after the war was a German six-cylinder reversible Diesel engine which developed about 115 brake horse-power at 500 revolutions per minute. Unfortunately, the engine was not in a condition to be run, but an examination of the design showed that that solution was quite a possible one.

During the war a great development was made with the coastal motor boat. The first boat was a 40ft. hyroplane equipped with a Thornycroft 250 brake horse-power engine running at 1350 revolutions per minute. Engines of 1000 horse-power were now fitted, and the weight had been reduced from 7 lb. to 3½ lb. per horse-power. The Sunbeam, Thornycroft and Green engines were fine examples of what skill and ingenuity could accomplish in design and workmanship, and well represented the advances made in recent years. Perfection, however, had not yet been reached, and there was room for improvement in clutches, reversing gears and many minor fittings.

Turning to heavy oil engines, the speaker held that the Diesel engine was undoubtedly the most important, and the fact had been recognised by the Admiralty since 1907. Starting from comparatively small powers, submarine engines had been developed up to 3600 brake horse-power in the J class submarines. There was a popular notion abroad that the German submarines were fitted with higher powered engines than were the British. That was untrue, and, class for class, the power of the engines fitted in the British boats was greater. It was true that at the end of the war the Germans were building a submarine with 6000 brake horse-power engines, but it was never completed.

Important research work had been done at the West Drayton Admiralty Research Laboratory during the last four to five years. It had been found possible to increase the horse-power obtained from a given unit, and he hoped that even larger powers would be reached in the case of fast-running engines for naval service. He expressed the desire that it would prove possible to make known some of the research results by means of papers read before the various engineering societies.

Mr. A. Perman explained the work of the marine section of the Society with regard both to its co-operation with the Port authorities and classification societies and also to the work of standardisation. That section of the Society was, he said, well organised as to legal matters and in a position to give advice on matters affecting the welfare of the trade. He appealed for the support of the builders of large marine Diesel engines, as regarded both the work of the Society generally, and the forthcoming exhibition in particular.

Dr. H. S. Hele-Shaw, President of the Institution of Mechanical Engineers, spoke wishing the undertaking of the Society with regard to the 1923 exhibition every success, and the chairman, Lieut.-Colonel G. A. Cole, President of the Society of Motor Manufacturers and Traders, Limited, briefly responded on behalf of the Society.

GOOD ADVICE TO PUBLICITY MANAGERS.*

THE editor's duty, like most people's, is, in essence, quite a simple one. It consists, briefly, in the production of the best and most interesting paper possible. To do this he must satisfactorily perform the following three functions:—(1) Accurately gauge his readers' requirements; (2) select matters supplying these requirements; and (3) present this matter in suitable and attractive form. Bearing these facts in mind, the editorial viewpoint will be readily understood.

Submitting matter for publication is, therefore, very like entering a competition; space is limited, and the most suitable contribution wins. Knowing the viewpoint from which matter is judged, it should not be very difficult to fulfil requirements. The trouble with publicity men, as a rule, however, is that they do not trouble in the least to discover what the editor wants, and therefore frequently fail in their efforts to secure editorial notice.

There should be no broadcasting of duplicated or "circular" articles. Whatever is submitted to a first-class publication should be, as far as possible, exclusive to that publication, and when this is not so the fact should be stated. The same illustrations should not be sent to half a dozen different journals. Firms having a reputation for following this course do not get many notices. Attend carefully to those journals that publish general notes and topical trade news. Much incidental publicity may be secured by keeping editors of such journals advised of news items suitable for insertion.

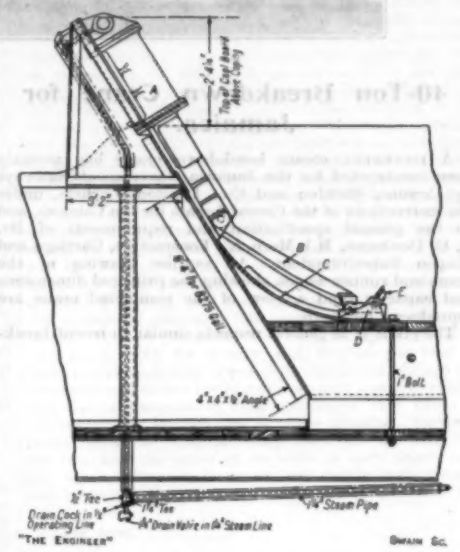
There is also a prevalent idea that the purchase of advertising space carries with it some unwritten right to a notice in editorial pages. This may have been so in the bad old days, but is not the case amongst reputable technical journals nowadays. The great publishing concerns of to-day are proof against blandishments of this kind. Neither does this sort of thing help the advertiser. Very little thought will make it evident that such a policy would be an extremely destructive one for an editor to follow. Were this plan put into effect, papers would be filled with matter selected, not for its news interest, but for its revenue-earning capacity. Lack of interest means loss of circulation, and as, after all, the advertiser is primarily concerned with circulation, and, above all, circulation of the right kind, it will be evident that in applying the merit test to all contributions, and so retaining the interest of the best type of reader, the editor indirectly best serves the advertiser.

* From an address presented to the Coventry Branch of the Institute of Production Engineers by Mr. Walter L. Fisher, Vice-president.

Coal Pusher for Locomotive Tenders

ON many large American locomotives the fireman is kept busy stoking in order to maintain the steam pressure, so that his time is fully occupied in shovelling coal and keeping his fire in good condition. This is particularly the case with very large engines hauling heavy trains and with shunting engines where the heavy blast is continually tearing the fire. Under such conditions it is necessary that the fireman should have plenty of coal always within reach and not find it necessary to go back into the tender and shovel coal forward to the footplate or firing deck. In a few cases an extra fireman or coal passer has been employed to keep the coal worked down to the footplate. A better and more economical way is to apply a mechanical coal pusher, under the control of the fireman.

A coal pusher used by the Chicago and North-Western Railway on the tenders of large shunting engines in goods yards is shown in the accompanying illustration. The cylinder A, with its guides, is mounted on an extension



COAL PUSHER FOR LOCOMOTIVE TENDERS

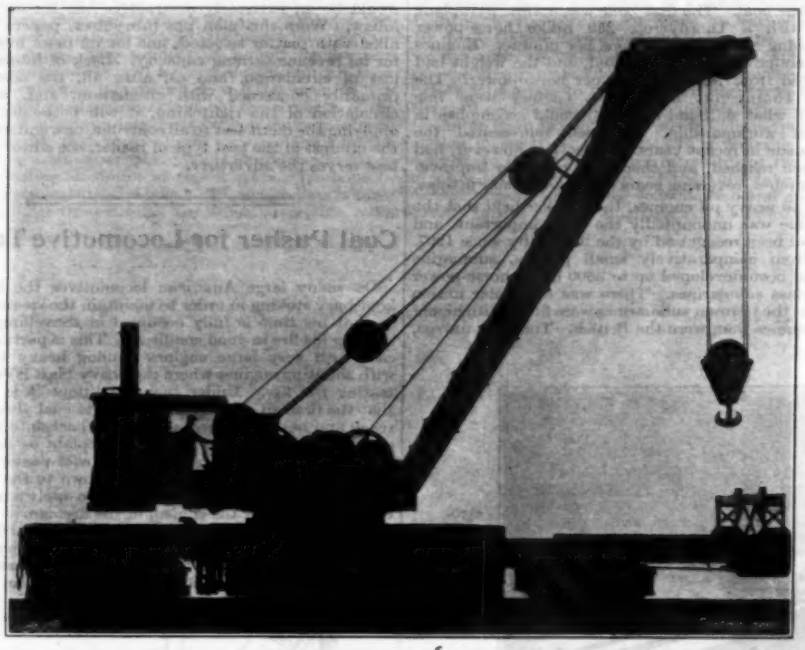
of the inclined back plate of the coal space. A connecting-rod B is attached to the crosshead and carries a broad shoe or pusher D, which travels on the curved guides C. Pivoted lugs E on the front of the shoe engage large lumps on the forward stroke, but fold down as the shoe is drawn back through the coal.

From an attachment on the boiler head in the cab a 1¼in. steam pipe is led back along the underframe of the tender and up to the steam chest of a rotary valve on the top cylinder head. A ¼in. heater pipe is laid along the steam pipe, the two being cased in asbestos lagging which is covered with a sheet metal jacket. From the other end of the rotary valve a 1¼in. exhaust pipe is led downwards. The fireman controls the operation by means of a small valve wheel and vertical ¾in. rod at the forward end of the tender, the lower end of the rod being forked to fit into the similar wheel of a globe valve on the steam pipe. When this valve is open the piston of the inclined steam cylinder makes slow strokes, forcing the shoe downward through the mass of coal and thus pushing the coal forward to the footplate. With this device the physical or muscular work of the fireman is reduced and he can give his time to better handling of the fire, thus conducing to efficient and economical work by the locomotive.

THE ASSOCIATION OF CONSULTING ENGINEERS.—There is a "something" about the dinners of the Association of Consulting Engineers which is missing from any other similar entertainment with which we are acquainted. There is a sense of *camaraderie*, and of everyone knowing everyone else, that puts the visitor at once at his ease, and makes it certain that he will enjoy himself. This year's dinner, which was excellent in every way, was held at St. Stephen's Club on Wednesday evening last. There was an attendance of well over a hundred, and the chairman was the chairman of the Association—Mr. A. M. Sillar. The speeches, both of those who proposed and of those who replied to the toasts, were well above the average. Mr. Frank Gill—himself once a member of the Association, but now debarred from membership owing to his official position—gave the toast of "The Association," which was replied to by the chairman. The toast of "Engineering Industries" was proposed by Mr. A. H. Preece and felicitously replied to by Sir T. O. Callender. The "Bench and the Bar," introduced by Mr. J. Mitchell Moncrieff, evoked charmingly witty replies from Mr. Justice McCardie and Mr. G. M. Freeman, K.C.; while the toast of the "Guests," which was proffered in a characteristic speech by Mr. S. R. Lowcock, the society's hon. treasurer, was responded to briefly by Sir Evelyn Murray, K.C.B., Secretary to the Post-office, and at greater length by Mr. E. Honoratus Lloyd, who called forth much merriment by his piquant criticisms of the speeches made by the various proposers of the toasts. Altogether it was a most delightful evening.

BREAKDOWN CRANE FOR JAMAICA

COWANS, SHELDON AND CO., LIMITED, CARLISLE, ENGINEERS



40-Ton Breakdown Crane for Jamaica.

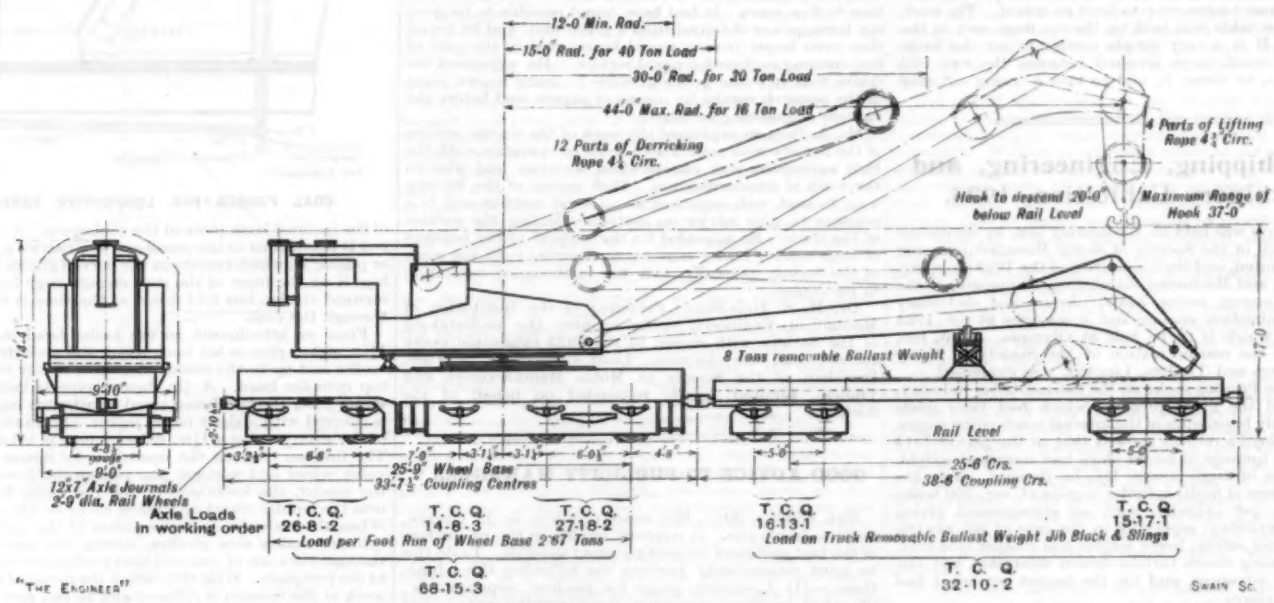
A POWERFUL steam breakdown crane has recently been constructed for the Jamaica Government Railways by Cowans, Sheldon and Co., Limited, Carlisle, under the instructions of the Crown Agents for the Colonies, and to the general specification and requirements of Mr. P. C. Dewhurst, M.I. Mech. E., Locomotive, Carriage and Wagon Superintendent. An outline drawing of the crane and runner wagon showing the principal dimensions and capacity, and a view of the completed crane are reproduced herewith.

The crane is in general respects similar to recent breakdown cranes of the ten-wheeled type, but in addition to the particular interest that attaches to it by reason of its exceptionally high capacity—we believe it is the highest capacity breakdown crane so far constructed in England—coupled with low axle-loads and weight per foot run, it has certain special features in its wheel base and other running arrangements, introduced by Mr. Dewhurst, to enable a crane of such capacity to negotiate the unusually difficult conditions of the Jamaica Government Railway lines, which include curves of 240ft. radius combined with gradients of 1 in 30 uncompensated.

Among these special features are the provision of considerable lateral travel of the extreme axle of the crane controlled by axle boxes on the "Cartazzi" principle; in addition, the springs of these axle-boxes are equalised with those of the adjacent axle-boxes by levers outside, which, however, had not been applied at the time the photograph from which our engraving was made, was taken. It was further necessary, owing to the quick variations in super-elevation on sharp curves, to depart from the usual crane practice of taking the weight directly on the side bearers of the bogies; special bogie centres being provided, together with slippers arranged to transmit the weight directly on to the side bearers when the crane is in lifting trim. The jib is arranged as an articulated member radiating from the crane centre pillar when travelling as the curves met with preclude a limiting position.

The lifting capacities are 40 tons (maximum load) at 15ft. radius at 15ft. per minute; 20 tons at 30ft. radius; and 16 tons at 44ft. (maximum radius) at 37.5ft. per minute. In order to meet these demands whilst keeping within the limits of 2.7 tons per foot run, together with a maximum axle load of 14.5 tons, part of the counterbalance weight required when lifting is detachable, being carried on the runner wagon when travelling. This weight —8 tons—is lifted by the crane itself, and placed on the main frame. The crane is then turned through 180 deg. for the attachment of the balance weight to the rotating frame under the boiler. The minimum radius is 12ft.

The crane is of the standard—4ft. 8½in.—gauge, and conforms to the loading gauge of the Jamaica Government Railways, which is greater than usual, viz., 15ft. at centre and 10ft. 3in. in width. The cylinders are 8in. by 12in., the boiler having a total heating surface of 67.75 square feet, with a grate area of 11 square feet, and is able to evaporate 700 lb. per hour, at a working pressure of 100 lb. per square inch. The length of the main frame of crane is 31ft. 8in., and that of the runner wagon 36ft. 4½in., the combined total length over couplers being 72ft. 1½in. The total weight of the crane in travelling trim is 68 tons 15 cwt. 3 qr., and that of the runner wagon, including the 8 tons balance weight, 32 tons 10 cwt. 2 qr. Westinghouse air brakes and M.C.B. pattern central automatic couplers are provided.


12-0" Min. Rad.
15-0" Rad. for 40 Ton Load
30-0" Rad. for 20 Ton Load
44-0" Max. Rad. for 16 Ton Load
12 Parts of Derricking Rope 4¼" Circ.
4 Parts of Lifting Rope 4½" Circ.
Hook to descend 20'-0" below Rail Level
Maximum Range of Hook 37-0
8 Tons removable Ballast Weight
Rail Level
14'-4"
9'-10"
4'-8½" gauge
9'-0"
12"x7" Axle Journals
2'-9" dia. Rail Wheels
Axle Loads in working order
T. C. Q. 26-8-2
T. C. Q. 14-8-3
T. C. Q. 27-18-2
T. C. Q. 16-13-1
T. C. Q. 15-17-1
Load per Foot Run of Wheel Base 2·67 Tons
25'-9" Wheel Base
33-7½" Coupling Centres
25'-6" Crs.
38'-6" Coupling Crs.
Load on Truck Removable Ballast Weight Jib Block & Slings
T. C. Q. 68-15-3
T. C. Q. 32-10-2
"THE ENGINEER"
SWAIN Sc.

GENERAL ARRANGEMENT OF 40-TON BREAKDOWN CRANE

THERE is a prospect of progress being made with the scheme of a light railway between Longridge, the end of the Preston and Longridge Railway, and Hellifield, where what was the Lancashire and Yorkshire joins the Midland between Skipton and Settle. The line will be 24 miles in length, and will open up the lovely Hodder Valley.

WATER AND TIDAL POWER.

ON Monday, November 20th, Mr. R. F. Hindmarsh, M. Inst. C.E., Chief Engineer, Tyne Improvement Commission, delivered his presidential address to the Newcastle-upon-Tyne Association of the Institution of Civil Engineers, and took for his subject "The Utilisation of Water and Tidal Power." In the course of his remarks the President said that water wheels were in use 3000 years ago on the Nile, and that similar wheels continued in use without improvement until the early part of the eighteenth century; wheels turned by tidal currents had also been used in this country and in America, Spain and France, but on account of their insignificant magnitude and primitive design, and also owing to their intermittency, these were not suited to ordinary industrial uses.

The water turbine was evolved in 1823 by a Frenchman, and such machines were capable of developing much greater powers and of operating at higher speeds than the old water wheels which they gradually displaced, although in some places water wheels were still doing useful work. Recent improvements in the water turbine and electrical appliances had made possible the great advance which had been made in hydro-electric work in the last few years. The total potential water power in the world was, said Mr. Hindmarsh, estimated at 200 million horse-power, but so far only about 25 million horse-power has been utilised. It would, however, take the whole output of the mines of the United Kingdom to produce as much energy as is at present produced from water power in the world. The United Kingdom at present only developed about 200,000 horse-power from water power, and had not nearly the resources of many other countries, but there were still possibilities of much further development, especially in Scotland, it being estimated that energy could be developed at an economic rate from certain undeveloped water power resources nearly equalling the amount developed at Niagara Falls or an amount equal to the power generated in the 410 public steam power undertakings for electric supply to railways and tramways in Great Britain.

Although deficient in inland water resources, the motion of the tides around the coasts of this country represented, continued Mr. Hindmarsh, an enormous possible source of power, the western and especially the south-western coasts of Great Britain being particularly suitable for tidal power development. A scheme had seriously been put forward recently for the development of power from the tides in the Severn, and the French were proceeding with the erection of a tidal power station near Brest at a cost of 28,000,000f. The President referred to the many objections to erecting barrages in connection with tidal power schemes across navigable tidal rivers, and stated that it would seem necessary if tidal power were to be utilised to select places on the coast where navigation and other important interests would not be interfered with.

Few things were, he continued, more essential to industry and the welfare of the community than cheap power, and he therefore urged the necessity for engineers to give the question of utilising water and tidal power their closest attention. Coal was too valuable and would probably be too much in demand for other purposes to be burned under steam boilers if other economic sources of power were available.

IRON AND STEEL INDUSTRY IN JAPAN.

THE iron and steel industry in Japan has been in a very depressed condition during the past few years, and still shows no signs of improvement. Various means of relief have been proposed, but none has so far been tried or carried out. Some of the works have been closed down entirely, while others are on short time. Among those operating are the Japan Steel Works and the Kamaishi Iron Foundry, both of which are turning out about 100 to 120 tons of pig iron or steel daily. The Government steel works at Yawata are producing about 30,000 tons of pig iron and steel every month, a figure which shows an increase over that for the same period last year, but the increase is not the result of a revival of demand, being

due to the resumption of work by some of the furnaces that were under repair last year. The Oriental Steel Works, which are now operated under Government supervision, is working a 150-ton furnace, while the Kenjiho Iron Foundry in Korea is turning out 200 to 250 tons of pig iron daily. With the exception of that produced by the Yawata Steel Works, most of the pig iron output is for casting purposes, and not material for steel making simply, because the former commands a better price. With regard to steel making, all the establishments except the Government works have been restricting their output; consequently the total production for the first six months of the year will, it is anticipated, show a decrease of about 10 per cent. as compared with the latter half of 1921.

There is no profit to be made in the iron and steel business, as the present market price is barely sufficient to cover the cost of material and wages, and the manufacturers are at a loss as regards business expenses and interest on their capital. The main obstacles to the success of the iron industry in Japan, as in other countries, are the high wages and high cost of coal, and until these adverse conditions have been rectified it can hardly be expected to be placed on a substantial basis.

The pig iron market showed some improvement in the spring, but owing to the tightness of money it has again slumped since April, and the present quotation is about 60 yen per ton. The dullness of the market is due to the slackness of demand and over supply, owing to increased imports. The import of pig iron from January 1st to July 31st amounted to over 156,000 tons compared with 123,750 tons for the same period of 1921.

Something like 40 per cent. of the import is Indian pig iron, which is quoted at 52 yen per ton delivered in Japan, or 8 yen less than the domestic article. The stock of pig iron in January last was estimated at 212,868 tons, though it has since been reduced to 186,236 tons; but, in view of the decreased demand at present, even that must be considered a very large stock.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Reviving Iron Trade.

If one may judge from a straw which way the wind blows, the indications are that it is in a more favourable direction so far as Staffordshire trade is concerned. Recently, one or two things have happened calculated to engender a more hopeful feeling regarding the situation. One of them is the fact that as the result of the ascertainment of selling prices during September and October, ironworkers' wages regulated by the Midland Iron and Steel Wages Board advance automatically 2½ per cent. The point to be emphasised is that this is the first time for two years that the ascertainment has been in an upward direction. It amounts to only 1s. per ton, but it is regarded as a symptom that the downward rush has been arrested. The advance in the net average selling prices is due, however, mainly to the increased make of best bar iron for engineering, which necessarily carries the highest market prices. When it is remembered that since the beginning of 1921 the average selling price of iron fell nearly £23 per ton, it will be realised how welcome is the change. This turn of events, accompanied by the reduced rail rates which are now operative, should be of material assistance in getting the wheels of industry to move again.

Lessened Unemployment.

Further indications of improving trade in the Midlands, particularly so far as the Birmingham area is concerned, are provided by the unemployment returns, which show the number of workless to be steadily decreasing. The weekly decline, although not very marked, has been, as I pointed out last week, steady and continuous, and the figures for the West Midland area show a falling off since August from 223,000 to 168,000, a drop of 55,000. In the Greater Birmingham area this week there has been a continuance of the general decline, the number of workless having decreased on the week by 1648, leaving the number of persons now without work 55,373. Other favourable factors in the trade situation are the increasing volume of inquiries which manufacturers are receiving; the better employment of the Birmingham brass foundries on orders for fittings used by cabinet makers and plumbers; the improvement in the position in the wagon building shops as the result of recent orders for rolling stock; and the confident anticipation of a good volume of business as the result of the shows on the part of motor and motor cycle engineers.

The Rail Freights Reduction.

The iron and steel trades of this area welcome the concessions and modifications in railway rates, only announced as this letter was going to press last week, on iron and steel, with the fuel and raw materials used in their manufacture. The step constitutes a distinct advance on anything done by the railways up to the present. It indicates that at last the companies are beginning to realise the importance of low rates in order to get back to normal trade conditions. It is vital for trade revival in 1923 that the coal, iron, and steel industries should be stimulated by every means that can be devised. Recent years have been very difficult for the iron and steel concerns in this district, equally with other parts of the kingdom, and there is general agreement that the relief now proffered is a real one. The Midlands, on account of their geographical position, are always under a disability in regard to long-distance transport. The more the initial cost, either of raw materials or of transport, can be cut down the better for all departments of the rolled iron and steel business, and these railway freight reductions should aid considerably in stimulating the revival of Midland and Staffordshire industry. As to the actual effects of the concessions granted, it appears that the blast-furnaces will benefit just in proportion to their remoteness from ore and coal and coke and limestone supplies. South Staffordshire stands out as the leading example. It imports the bulk of its supplies of coke from North Staffordshire, Yorkshire, Lancashire and South Wales. The reduction of the fuel freight maximum from 3s. to 2s. will have no result on hauls from North Staffordshire and sources nearer home, because the rates were already within the 2s. plusage. A saving of 5d. to 6d. a ton will, however, be obtained on the carriage of coke from the Sheffield district into South Staffordshire. In the case of the more distant Yorkshire areas the difference will be 8d. to 9d. per ton. Some of the more accessible Lancashire supplies are not more than the equivalent of 4d. outside the 2s. radius. Consignments from South Wales will get the full benefit of the 1s. reduction. Ore for the South Staffordshire pig iron industry now comes chiefly from Northamptonshire and limestone from Derbyshire. At some furnaces it is estimated that the readjustment will represent a saving of 2s. per ton of pig iron produced. Respecting North Staffordshire, Derbyshire, Northamptonshire and districts farther north, the saving will not be so great. The entire reduction is a valuable step towards the rehabilitation of South Staffordshire trade. The drop in the rates on finished material is regarded by many iron and steel masters in this district as the most important concession of all. On long-distance traffic it may involve a saving of about 5s. per ton. Under the head of Class C traffic the increase on the basis rate is limited to a maximum of 8s. per ton. Previously the increase has occasionally amounted to 13s. per ton. The new rates will be very helpful to firms sending manufactured iron and steel to the ports for shipment. It is then, with unquestioned gratitude, that Midland iron and steel masters look upon the action of the railway companies, and, as gratitude is the lively anticipation of favours to come, they venture to still hope for further relief in the future.

Fluctuating Prices of Belgian Iron.

The Staffordshire ironworks do not show much improvement, and are still subject to keen Belgian competition. Continental prices for nut and bolt iron are continually fluctuating. The sharp rebound of Belgian prices last week has been followed by a relapse, and nut and bolt iron can now be bought at £6 10s. f.o.b. Antwerp, if buyers are prepared to wait for delivery. Adding £1 7s. 6d. for freight the delivery price is £7 17s. 6d., about £1 15s. below the figure at which mills at home find the business worth having. Leading Staffordshire and Lancashire houses still quote £9 15s., but this is not a rock bottom price, and business is done in some instances at £9 12s. 6d. and even £9 10s. The disparity between home and continental prices remains too pronounced to give the local producer much chance of improving his order book. He occupies a more favourable position with regard to fencing iron, but here again demand has become languid. Merchant bars are in rather better request. Prices, though they undergo little perceptible change from week to week, are moving down rather than up. Good second class bars are quoted £10 10s. to £10 15s. Marked bars are the one static feature in the market remaining firm on the basis of £13 10s. Galvanised sheets continue a strong market, on the basis of £17 10s., firms well placed asking as much as £18.

Steel Values.

The local steel works continue well employed in the supply of finished steel. They are finding less competition from the North, where some makers have lately demanded a premium of 2s. 6d. for steel sent into this district. Steel makers are not paying too much attention to continental prices, and are quoting from £7 to £7 2s. 6d. for billets. Belgian material is this week again on offer, being quoted £6 10s. delivered. This is a figure just able to attract business, where the conditions, particularly as to slow deliveries, are not too embarrassing. Very long periods for delivery are named by Belgian steel works, which are fairly filled up with orders; in some cases from two to three months is cited as the period for the execution of the order. This condition, as a rule, is a bar to business.

Firm Pig Iron Prices.

Pig iron producers continue to find slightly better inquiries. Some of the engineering works are becoming more active and are, therefore, better buyers of foundry iron. On Birmingham 'Change to-day—Thursday—consumers of pig iron vainly urged their claims to participate in the benefit, amounting in the case of South Staffordshire to about 2s. per ton of pig iron, derived from the railway freights reduction. Producers answered that the relief had long since been discounted, and they adhered firmly to their quotations. Furnace owners state that they are unlikely, with demand in its present condition, to bring into operation any of the furnaces in this area, of which a number have been idle for nearly two years.

Engineering.

Structural engineers are finding more inquiry, with more contracts open for settlement, especially in connection with foreign railways. They have booked fairly numerous contracts, although they individually call for only small tonnages of steel. No great development is regarded as likely during this month, but the outlook is considered quite hopeful for the New Year.

Cannock Chase Miners' Wage Increase.

For the fourth consecutive month the wages of the Cannock Chase miners will show an increase for the month of December. The Wages Board has intimated that the increase will be 3.38 on the wage basis, this being equal to an advance of 3d. per day in the minimum wage of stallmen, whose pay will now be 9s. 8d. per day, as against 9s. 5d. in November.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER, Thursday.

General Outlook

THE more cheerful feeling in the iron and metal markets here continues, but it is not based on any decided improvement of business, but rather upon sanguine anticipations of an improvement next year. It is felt that if a large proportion of the "dole" is employed upon work of any kind rather than upon the demoralisation of the worker, a fillip will be given to industry and a larger demand for materials will result. The electrification of the railways will certainly call for supplies of metal, and with some Government assistance this work might be carried out promptly, although the companies might not be justified in embarking upon it without some financial aid.

Metals.

The slight fall in the copper market seems to be checked for the present. It was perhaps too confidently assumed that the upward movement in the American exchange was likely to be continuous until a par of exchange was reached; but this, although possible, is not altogether probable. The chances seem to be that the raw copper market will remain comparatively steady for some time yet, but that when a permanent movement sets in it will be in an upward direction. There is no good reason now why the consumer of raw copper should not hold fair stocks, for the prospects of higher prices in the copper market are better than the prospects of lower prices. Probably this is quite appreciated by the copper consumers generally, but the lack of spare capital induces them to work upon low stocks. The reports from America suggest that while the output of copper is slowly increasing, there is not a corresponding increase in the consumptive demand. Here the total demand for copper is no doubt checked by the disproportionately high prices of the manufactured metal and its alloys. Certainly, an export trade to India is hindered by these prices, just as it is for the similarly high prices for manufactured iron. So far as confidence in buying is concerned it is not always realised that rightly proportioned prices have a great influence. In the market for tin the set-back of prices seems to be checked for the time. The total amount of the rise was nearly £35 per ton from the lowest figure in May and June, and the loss amounts to about £10; so that the present prices are still some 16 per cent. higher than they were in the summer. Whether the general condition of the consuming trades is 16 per cent. better than it was then may perhaps be doubted. The market seems to believe that the American consuming interests will be short of tin early in the New Year because they have not been buying for some time; but this is not altogether certain, and there are people who believe that the American consumer has quite ample supplies of the metal. In lead there has been very little change to note. The prices both for foreign and English pig lead keep steady, although they are slightly below the highest point. The tendency to buy for prompt use only is still in evidence, and the backwardation does not tempt very many consumers to buy for delivery in three months. Spelter has made rather a rapid recovery from the set-back of £4 per ton, and the price as we write is very nearly at the top again. Buyers, however, are rather nervous about purchasing at these prices.

Pig Iron.

The condition of the Manchester market for pig iron is just the same. There is a moderate and steady demand from the ironfounders, and it is generally believed that these people are rather better off for work than they were, but the supply is ample for all requirements, and it is not clear that the efforts of the Derbyshire makers to raise the price of No. 3 will be successful. At any rate, it is still easy to buy No. 3 at 90s. per ton delivered in Manchester, although one does not hear now so frequently about lots being sold much below this figure. The reduction in the railway rates will, however, permit the Northamptonshire makers to compete more easily than before. Reports from Cleveland suggest that the market there is weaker, but this does not interest Manchester founders very much. A more interesting point for them is the reduction in the Scotch railway rate, which, it is hoped, will enable sellers of Scotch iron to bring the price down to within 10s. of that for common iron. This has not been done yet, but should it take place one may expect that the consumption of Scotch iron in Manchester will begin to resume normal proportions.

Finished Steel.

There are reports about of the revival of orders for new ships, and this is causing some hope to arise in the steel trade. One report is to the effect that large orders, up to 40,000 tons, have been placed for ship plates; and it is certainly true that some of the idle steel works in the North-East district are to be re-started. One cannot, however, believe that any serious revival in shipbuilding can yet take place. Some of the Midland steel makers are now trying to obtain rather better prices in the Manchester district.

Scrap.

There is perhaps a slightly improved feeling in the market for old materials. It began with steel scrap, but it seems now to be spreading to cast scrap, and dealers are hoping that wrought scrap will feel the improvement before long. Heavy steel melting scrap is quoted at 60s. on trucks at a Lancashire station. Good lots of broken machinery cast iron are quoted at 77s. 6d. to 82s. 6d. per ton according to quality. One does not hear so much now of offers of foundry scrap at under 75s. per ton.

Manchester Association of Engineers.

Instead of a dinner, the Council of the Manchester

Association of Engineers decided this year to have a social evening and smoking concert, which was held on Saturday evening last at the Midland Hotel. There was a very satisfactory attendance of members and friends. Mr. Daniel Adamson, the President, who occupied the chair, took the opportunity to refer to the need for a central building in Manchester to accommodate all the engineering societies and other technological bodies. He contended that the Manchester Association of Engineers should take the lead in the suggested movement. Mr. Adamson submitted to the meeting a sketch plan of a suitable building of five storeys, the probable cost of which, he said, was about £50,000, £30,000 for the building and £20,000 for the land. The building proposed would contain a hall capable of accommodating 300 persons. It will be remembered that the present Engineers' Club is the outcome of a similar scheme promulgated before the war, but the building is not nearly large enough for the purposes which Mr. Adamson mentioned. It might, however, be possible to obtain a building in close proximity to the club which, with some modifications, could be adapted to the purposes of a central meeting house.

BARROW-IN-FURNESS, Thursday.

Hematite.

The hematite iron trade is now enjoying an exceptional period of activity. It is almost safe to say that not for many years has there been such business. In the past the steel works in the district have taken a quantity, but as there is practically little being done in the steel trade at present, the bulk of iron being sold is considerable and as large as it has been for ten years, when more furnaces were in blast. More furnaces will be put in blast shortly, and there is talk of an addition of two in Cumberland. The American trade is falling off, as was expected, for the recent deliveries were a result of the coal strike in America. All other sources of business are good, both abroad and at home, and deliveries are now being booked for next February. The business in special classes of iron is better, and the demand for spiegel and manganese is satisfactory.

Iron Ore.

The iron ore trade is better, and there is more being brought up in the district. Apart from the local consumption, orders are being received from other iron-smelting centres, and deliveries are being sent both by rail and coast steamers. Foreign ore is held in such stocks at the docks yet that a minimum is being imported at the present time.

Steel.

There is little being done in the steel trade, and the rail mills are not likely to re-start until next January. The market is better, and orders have been secured for certain quantities for Colonies. It is also expected that English railways will be placing orders for heavy sections in the early future.

SHEFFIELD.

(From our own Correspondent.)

Steel Trade Progress.

THERE is additional evidence this week of the gradual recovery of the heavy steel trades of Sheffield. The unemployment figures have again fallen, though only by about 500, and much less short time is being worked. The basic steel branch is really busy, and the demand for acid steel, though still short of what it ought to be, is increasing. The output from the heavy furnaces of the city and district to-day is probably equal to that of pre-war days; but this, of course, does not mean that the productive capacity is fully employed. There were such large extensions in consequence of the war that Sheffield now requires a great deal more work than ever before to keep it fully employed, and the depression of the past two years has been so acute that grave fears have been expressed as to whether the city would ever again enjoy complete prosperity. So far as the armament side of its equipment is concerned, those fears remain. Even when the orders for the two new battleships are given out—and Sheffield is very much surprised and disappointed that they have not been given out yet—they will not keep the armament shops busy long, and it seems likely that plants on which millions of money have been spent in the interests of the nation will for the future be more or less reduced to a state of idleness.

Huge Productive Capacity.

But in other directions it is possible to take an optimistic view, to believe that Sheffield has not over-extended its resources, that the time may come when there will be full employment for its workpeople and a return on the capital which investors have put into its industries. This is a dream of the future with regard to several departments, which are not even doing a pre-war trade yet; but in regard to heavy steel it seems capable of early realisation. Among the extensions of recent years are the fourteen great furnaces, each of 60 tons capacity, which Messrs. Steel, Peech and Tozer erected at Templeborough. For eighteen months these furnaces lay quite idle, but a few months ago work began to be found for them, and now seven are employed, and are turning out between 4000 and 5000 tons of steel ingots per week. At Parkgate there is full employment for a plant which is 50 per cent. greater than was the case before the war, and which is to be further extended. The heavy works at the east end of Sheffield are, generally speaking, better employed than they have been since the end of 1920, and one of them is on full time. Prices are stiffening. There is nothing nominal about the official quotations for pig iron now, the prices being firmly maintained and realised, while the cost of scrap has gone up. It was on this account that the steel makers, last week, put up the prices of hard basic billets by 10s. a ton, to £8 15s., and the question of a similar advance on acid Siemens billets is under consideration. It is generally agreed that prices will not go any lower, and that those who have been withholding orders in the hope of further reductions would be well advised in placing them now.

Railway Supplies.

Further orders for locomotive building have been placed since my last letter, and although none have come directly to Sheffield, the city is pretty sure to receive some work in connection with them. The condition of things in the axle, tire, and spring departments shows a considerable improvement, and confidence in future expansion is well maintained. To the optimistic speeches which I quoted last week has now to be added one by the Master Cutler (Mr. R. W. Matthews), who is engaged in the railway steel trade. Speaking last week-end, he said he knew that there were in the offing very considerable orders, portions of which were likely to find their way to Sheffield. "The railway companies," he said, "spurred on by the Prime Minister and the Chancellor of the Exchequer, are at last going to put their hands into their pockets and give us something fit to ride in and safe to ride in." It is fully expected that a large amount of work will be forthcoming in the New Year in connection with renewals and developments on British railways, and there is also further Indian business in view. There is a large demand for coal wagons, and it is reported that Clayton Wagons, Limited, of Lincoln, have booked orders for the construction of several hundreds of these vehicles. The fact that railway companies are pressing on with work is supported by the announcement that the directors of the Midland have decided to put their works at Derby on full time forthwith. This will affect 9000 men. For a considerable time the locomotive and carriage and wagon departments have only been working four days a week, with five in some instances, and it is about two years since the complete forty-seven hours were worked in a week.

The Reduced Railway Rates.

The reductions in railway freights, which came into operation on the 1st of this month, were very welcome in Sheffield, where the handicap of high rates is severely felt. The reductions apply chiefly to such trades as are carried on in this district. The most appreciable one is in regard to iron and steel in Class C, where the 75 per cent. increase of January, 1920, is to be brought down to 60 per cent., with a maximum increase of 8s. per ton. This represents a considerable concession on long-distance traffic, the rates for which, under the old scale, might run up to 13s. per ton. Mr. Sydney J. Robinson, presiding at the Chamber of Commerce luncheon to Sir W. Joynson-Hicks last Friday, expressed the opinion that the reductions would to some extent help in the revival of trade. He strongly urged, however, that a reduction in the charge for the carriage of coal was still imperative. The only drop now granted relates to the maximum increase on January, 1920, which is brought down from 3s. per ton to 2s., but this does not help Sheffield, as the coal used in the city does not come from long distances. They used so very much coal, said Mr. Robinson, that they must have it at low cost or cease work. Every ton of steel consumed 4 to 5 tons of coal, and he understood that, taking a large average, a shilling a ton in the freight of coal meant a difference of 4s. in the cost of the steel produced.

The Lighter Trades.

There are indications that the Government stocks of high-speed steel are approaching exhaustion, and a little revival in the purchasing of new material is noticeable, but the state of the trade generally is still very depressed. The crucible steel department is not a great deal better off. Makers of high-speed twist drills and other engineers' tools have no improvement to report, and file manufacturers are not booking enough work at present, though they have good prospects. The recent boom in electro-plate appears to be subsiding. There is a large amount of work still on hand, but new orders are not coming in so fast, and it is doubtful whether the present rate of activity will be maintained to the end of the year. There are some very large individual orders on hand for spoons and forks and small goods in cases. The cutlery trade, too, continues to be much better employed than it was up to a month or two ago; but here, again, the Christmas spurt seems to be easing down.

Public Utility Schemes.

A large number of schemes of engineering interest are on hand or projected by various authorities in the district. At Doncaster a Ministry of Health inquiry has been held with regard to an application of the Corporation for sanction to borrow £82,000 for purposes of water supply. About £40,000 of this sum is wanted in connection with the Armthorpe bore-hole and pumping station, and the remainder under existing schemes. The Corporation of Derby is proposing, with a view to providing work for the unemployed, to extend the existing tramway on Osmaston-road, at an estimated cost of £21,800. The Scarborough Town Council is faced with the serious problem of protecting the North Shore against subsidence, which is threatening the safety of the Royal Albert Drive. On the recommendation of Dr. Herbert Lapworth, it has decided to carry out experimental work and to press for Government assistance in dealing fully with the question. Dr. Lapworth recommends an elaborate system of drainage of the upper part of the cliff and Queen's Parade.

NORTH OF ENGLAND.

(From our own Correspondent.)

Brighter Trade Prospects.

THERE is abundant evidence that a period of greater industrial activity lies immediately ahead, and that a genuine trade revival is now in progress in the North of England. The past month witnessed a definite advance, and not only were six additional blast-furnaces put into operation, increasing the number now operating to thirty-six, but a local steel works restarted after eighteen months' idleness. The Skinningrove Iron and Steel Works are to be restarted next week, after having been almost totally idle since a week before last Christmas. There is also a better prospect of the Jarrow Steel Works being put into operation early next year. These works, which employ about 2000 men, have been idle since the miners' strike. In their annual report the directors of Dorman, Long and Co., Limited, state that substantial orders have been booked for constructional work and shipbuilding material. This firm has always been most active in the quest for work, but of all the other principal firms in the North-East Coast, it is true to say that it has better order books, and the inquiries now circulating in the market promise a steady improvement in industrial activity. The position is also made brighter by the placing of several more orders for new tonnage with Northern builders.

Traders and the Railway Rates.

The reduced railway rates, which came into operation on December 1st, have been accepted by traders in a spirit of thankfulness for small mercies. The reductions on carriage of raw materials and steel—finished and semi-finished—are certainly welcome, although the advantages conceded still leave ground for more marked assistance to a revival of the trade. For example, regret is expressed that coal and coke rates have not received more appropriate treatment. About the North-East Coast, short distance traffic necessarily suffers in that the distances the traffic is conveyed to blast-furnaces and steel works are not such as to make the maximum of 2s. effective. Among the principal difficulties which the iron and steel trade has long sought to eliminate may be mentioned the anomalies and the alleged unfair incidence of the flat rates generally, and their total abolition has been pressed. There is little ground for disputing that anomalies still exist, and create an unfair burden on short distance traffic, thus penalising the iron and steel industry on the North-East Coast in particular.

Iron and Steel Exports.

The shipments of pig iron from the Cleveland district during November amounted to 45,665 tons, compared with 62,175 tons for October. This decline was not unexpected. It was known that the American trade was past the peak, and the measure of the fall in the exports from the Tees to North America is precisely the measure of the decline. The exports to America fell from 38,578 tons in October to 15,600 tons in November. Trade with continental countries showed improvement, pig iron shipments to Belgium having advanced from 3826 tons in October to 6009 tons in November, and to France from 1295 tons to 2050 tons. Manufactured iron and steel exports showed no indication of improvement. Indeed, the month's total of 35,932 tons was 2666 tons less than the October figures. The home demand, however, has shown considerable improvement, and it can be confidently asserted that the export figures will henceforth show some improvement. Altogether the November aggregate of 81,587 tons of pig iron, manufactured iron and steel shipped from the district fell short of the October total by 23,388 tons.

Cleveland Iron Trade.

A quieter tone prevails on the Cleveland iron market, but this is the usual experience at this time of the year, as consumers confine their orders to very small quantities so as to avoid carrying over large accumulations during the stock-taking period. There is not, however, a very great surplus of iron for the open market, and substantial increase in the demand, such as may be probable after the holidays, would immediately see a shortage. An encouraging feature this week is a renewal of inquiries for substantial quantities of ordinary Cleveland foundry iron for shipment to the United States. The question of arranging forward freights is a difficulty, but any more Transatlantic sales would speedily alter the position. Owing to the high cost of production iron masters are loath to make concessions in prices, but on account of the quiet demand, there are now sellers of No. 1 and siliceous iron at 95. 6d., No. 3 G.M.B. Cleveland at 91s. 6d. to 92s., No. 4 foundry at 87s. 6d., No. 4 forge at 82s. 6d., and mottled and white at 80s. to 81s. per ton.

Hematite Pig Iron.

A brisk business is being done in East Coast hematite pig iron for both December delivery and also for requirements over the first quarter of next year. The foreign demand is still quiet owing to exchange difficulties, and the reluctance of British merchants to give extended credits, but the home demand is strong, and mixed numbers are quite firm at 93s. 6d., with No. 1 at 94s. 6d. per ton.

Iron-making Materials.

There is little business passing in the foreign ore trade. Sellers are getting anxious to realise some of the heavy stocks at the mines, and offer concessions. Best Rubio ore is now no more than 21s. 6d. c.i.f. Tees. Good medium furnace coke is still firm at 29s. per ton delivered at the works.

Manufactured Iron and Steel.

Better business is reported in the manufactured iron and steel trade, and the works are more actively employed. More orders are coming out, and manufacturers speak with greater optimism of the prospects. Prices generally are firm, but there has been some cutting for rail orders, and heavy steel rails are quoted £9 per ton, with fish-plates £13 to £14.

New Shipbuilding Orders.

The prospects in the shipbuilding trade are much more hopeful. Several orders have been secured by Northern firms this week. These include a new cargo steamer of 6400 tons deadweight for a Newcastle firm, three grain-carrying steamers for the Canadian Lakes, and three colliers for Newcastle owners, placed with the Smith Dock Co., Limited, South Bank; an order for a

steamer of 6500 tons placed with Messrs. W. Dobson and Co., Walker-on-Tyne; and a cargo steamer of 8000 tons to be built by the Palmer Shipbuilding Company, Limited, at Jarrow, for a Liverpool firm.

The Coal Trade.

The Northern coal trade situation is not much altered. Any change there may be is in the direction of a greater stringency, which is the result of the anticipated shortage in the output at the end of the month owing to the holidays, and the increased anxiety on the part of merchants to secure their full monthly supplies. Some of the pressure is also to be attributed to a fuller and more definite inquiry for early and later loadings. There is also a disposition to consider more freely next year's business. There is a feeling of intense relief in coal circles by reason of the contemplated re-institution of the three-shift system of trimming and teeming at the spouts. It will, however, take some little time for a sufficient number of trained men to become available. In the meantime, there is a great amount of dislocation at the collieries due to the lack of wagons. This means that in order to keep the pits going, teeming bye and heaping has to be resorted to, entailing extra labour in re-lifting later on. A fuller inquiry is reported from Norway and Sweden. Some of the large exporters are now receiving daily feelers, more or less definite, for supplies over the whole of next year. This looks as if they were intending at last to do something definite about their next year's contracts. Hitherto it has been impossible to get them to consider the present high prices, but as apparently there is no likelihood of cheap coals for some time to come, there are now good grounds for thinking that the Scandinavian trade will begin to improve until it reaches something approaching its former volume. All classes of steam coals are firm except steam smalls, with top prices quoted for any grade of screened or unscreened. Gas coals are a very firm feature of the market, with a fuller and consistently expanding inquiry. The coke market is only moderately steady for any class, but prices are generally upheld.

SCOTLAND.

(From our own Correspondent.)

Shipbuilding: November Returns.

DURING the month of November seven vessels of 25,538 aggregate tonnage were launched on the Clyde. The figures for the year to date give a total of 114 vessels of 369,326 tons aggregate, compared with 202 vessels of 421,845 tons in the same period in 1921 and 238 vessels of 628,816 tons in 1913. The last figures are the highest on record. The following two vessels practically accounted for the November tonnage:—The Veendam, twin-screw geared turbine, 15,000 tons, for the Holland-America Line, Rotterdam; the Dumana, twin-screw motor ship, 8500 tons, for the British India Steam Navigation Company, Limited, London. The year 1922 is below the average so far, and the figures for December are not likely to show an improvement, but the outlook is more hopeful.

New Work.

A number of new contracts have already been reported and others have just been announced, and there seems every prospect of busier times at the shipbuilding yards. The majority of the new orders are for passenger craft. Builders still find difficulty in quoting prices low enough to accommodate owners requiring cargo vessels; but every possible means towards economy is being studied, and it is expected that ere long all inquiries will be successfully met. More activity is promised on the lower reaches of the Clyde. A number of new orders for Port-Glasgow yards are mentioned, and one yard is said to have an order for four new vessels for a Leith firm. A yard in the district which has been closed down is to be re-opened shortly. Better times are also expected in Greenock. It is said that a firm of iron merchants in Greenock has completed orders for the delivery of 20,000 tons of iron to Greenock and Port-Glasgow yards at the beginning of the year.

Pig Iron.

The easier tendency in pig iron is still apparent, although actual quotations show little change. The export demand has fallen off rapidly and home requirements are not large enough to compensate in the smallest degree for the loss in shipments. Inquiries are fair enough, but firm orders are lacking. Practically nothing of any importance is being bought either in foundry or hematite. Unless an improvement sets in quickly some furnaces are likely to be put out of blast.

Steel and Iron.

An improvement in the steel trade is hardly noticeable, and the most that really can be said is, that conditions are no worse and that producers are still hopeful of an early turn for the better. Steel makers are still short of orders for plates, but the shipbuilding orders recently placed may improve matters in this department. Sectional material also is rather slack at present. Sheets are in fair demand in the thin gauges and the galvanised varieties are comparatively busy. Quotations for sheets are firm. No progress is reported from the bar ironworks. Foreign exchanges are against local makers, and buyers, more especially for export, are favouring continental makers. The majority of local establishments are still working well under their producing capacity. There is more inquiry for scrap material, but high prices limit buying to absolute requirements.

Coal.

A very brisk demand is still experienced for round coal and treble nuts for export. These sorts are well booked up, and collieries are not in a position to accept orders for prompt delivery, and it is practically only through second hands that odd lots can be secured. Prices for these are very strong, double nuts are firm, but singles, pearls, and dross are inclined to ease. A few shipments to America are still reported, and these are expected to continue for some time yet. The bulk of the shipments from East of Scotland ports went to Scandinavian and near continental destinations. Delays are occurring at Fifeshire ports owing to the number of steamers awaiting cargoes, and exports on occasion have severe demurrage charges to meet. The aggregate shipments for the week amounted to 268,536 tons, against 296,996 tons in the preceding week and 335,767 tons in the same week in 1913. The home demand for fuel for industrial purposes is quiet, but gas, electricity, railway, and household orders are increasing.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Trade Outlook.

AT the present time the coal trade, so far as steam qualities are concerned, is in a comparatively healthy state, inasmuch as practically all the leading undertakings are fully stemmed for the remainder of this month and the early part of next, while in the case of the other collieries they can well be described as comfortably off for orders. The docks are also pretty full, if indeed not congested with tonnage, and delays in steamers getting into berth are still being reported. There is every indication of the loading pressure continuing up to the end of the year, as the chartering of tonnage has maintained a fairly high level until this week. The question whether the coal market will hold firm next month is doubted in some quarters, and it is certain that the enquiry coming along is nothing like what it has been. The fact that leading descriptions cannot be secured for shipment this month is no doubt partly responsible for the falling off in the demand, while, of course, the comparatively high prices being asked is also detrimental to further business. Buyers abroad prefer to wait and look on in the expectation that before very long values will ease down. So far the amount of business done over next year or the first six months is not large; it is, in fact, well below the average. Foreign consumers are in no hurry to contract, and it is somewhat singular that coalowners appear to show no eagerness to sell far ahead, as they believe that they will be able to get good prices by waiting. Some shipping undertakings are reported to be negotiating for supplies over next year, and one or two collieries are understood to have sold all the large coal that they are prepared to dispose of at the prices they have obtained. In the case of best bunker smalls, it is stated that 50,000 tons have been sold at 16s. per ton, for delivery over the first half of next year, and 30,000 tons at the same figure for delivery over the whole of next year, this price being regarded as very good.

Miners' Wages.

Now that the Government has refused to institute an inquiry into the conditions prevailing in the coal-mining industry, mass meetings in this district have been held, and resolutions passed calling on the Miners' Federation to summon a national conference to consider the situation and the course of action to be taken. There has been a good deal of dissatisfaction in this district respecting the Buxton award concerning the lower-paid workmen in the coalfield on afternoon and night shifts. The outlook, however, on this matter is better. It is understood that the owners have met the men's contention as to the exclusion of overtime payments in assessing the amount of the subsistence allowance to be paid at the collieries where the men concerned were ordinarily paid six turns for working five shifts. In those cases where, however, the six-shift custom previously prevailed, the owners proposed that the whole of the week's earnings should be taken into account in deciding whether any subsistence allowance should be granted. The men's representatives are to meet the owners further to discuss this matter.

The Galloway Award.

In the Ebbw Vale district the Galloway award is the chief subject receiving attention. According to the interpretation of Dr. Galloway, the new price list came into operation on Monday last at the whole of the Ebbw Vale collieries. It was originally intended that this award should come into operation on November 1st, but as differences arose on the question of interpretation of certain clauses dealing with the question of allowances, it was mutually agreed to suspend its operation for one month to enable both sides to come to some agreement. During the past month miners' leaders, accompanied by the colliery officials, have visited all the working places for the purpose of ascertaining exactly what are the conditions of the various seams preparatory to discussing the subject of allowances. Discussions have taken place, but further negotiations between the parties will be conducted this week end, and if no definite decision is then come to, the case will again be submitted to Dr. Galloway.

Federation Re-organisation.

A plan for the reform of the South Wales Miners' Federation was outlined to the workmen at the Maritime Colliery, Pontypridd, on Saturday last, by Mr. Edgar Owen. No decision was taken regarding the scheme, it being thought better that the matter should be left in abeyance until further developments take place. The scheme is interesting, but is unlikely to meet with the approval of the majority of the leaders, especially the extremist section. After dealing with the question of pit and district committees, the plan provides that miners shall have as leaders men who have the conviction firmly established in their minds that co-operation and peace are what will best enable the industry to prosper. Contributions of members are to be kept back at the colliery offices and handed to one of the pit representatives who shall forward all money to the central committee. This would end all non-unionist troubles. The cost of working the organisation when it will function in the industry under co-operation and peace will be small compared with what it costs now, so a large sum of money will accumulate every year as surplus from contributions. It is proposed that this should be invested as capital in the industry to earn dividends for the miners, thereby making every man in the industry a small investor. Politics will have no place in the new organisation, but this does not mean that miners will not take part in political activity. It will be interesting to see what sort of a reception Mr. Owen's scheme gets from the Federation leaders.

Coal for Canada and the States.

Sir David Llewellyn, the South Wales coalowner and head of the firm of Llewellyn, Merrett and Price, Limited, of Cardiff, has arrived back at Cardiff after a short visit to the States and Canada, and has expressed very optimistic views regarding the prospects of future trade in Welsh coals for Canada in particular. He has announced that he has concluded, on behalf of his firm, a working arrangement with the Canadian Import Company, of which Senator Webster is the head. This company has already up-to-date coal-handling plant and discharging arrangements at Quebec and Montreal, which have been placed at their disposal. Breaking and screening equipment is also to be provided, and he anticipates great shipments of both anthracite and dry coals from this district when the river St. Lawrence opens for navigation next April.

Current Business.

The tone of the steam coal market is very firm for anything like early loading, as colliery stems are very full. Collieries are quoting up to 29s. for the best Admiralty large and from 27s. 6d. to 28s. for second Admiralty large. Monmouthshire coals are also higher in price and steam smalls are better, being firmly quoted at 17s. for the best. In the anthracite section the conditions are distinctly easier except for beans, pea-nuts, rubbly culm and duff coals. The demand for anthracite has fallen away, due very largely to the very mild winter.

Miners' Wages.

There is no change in the wage rate of miners for the current month. The certificate of the auditors for the month of October shows the percentage payable to the workmen is 15.36 on the 1915 standard rates. The men are entitled to a minimum of 28 per cent. on those base rates as per the agreement. The surplus in October is not sufficient to meet that claim without the sacrifice by the owners of £201,312 out of their standard profits. This has been the case every month since November last year, and the total amount forfeited by the owners has now reached the heavy sum of £2,866,000.

Latest News from the Provinces.

THE MIDLANDS AND STAFFORDSHIRE.

Premier and Colliers.

THERE was much discussion on 'Change in Birmingham to-day (Thursday) concerning the colliers' interview with the Premier and the attitude which the new Government as represented by its head has taken up in its first deal with this branch of labour. Among coal and ironmasters alike there was general approval of the answer which Mr. Bonar Law returned to the colliers. It is the general opinion of the best informed members of the Exchange that much more good to trade is likely to be effected by a strong Government such as Mr. Bonar Law's has now shown itself to be in handling labour problems than by any repetition of the "concessions" policy which was the constant outstanding feature of the Lloyd George Cabinet.

WALES AND ADJOINING COUNTIES.

Steel Works to Restart.

Guest, Keen and Nettlefolds, Limited, have decided to re-start their Dowlais works at Cardiff early in the New Year. There will be a considerable amount of preliminary work to do, and 400 men are to be taken on at once.

Coal Contract.

It is reported that the P. and O. Steamship Company has bought 100,000 tons of good second Admiralty large coals at 26s. per ton.

ROYAL INSTITUTION.—A general meeting of the members of the Royal Institution was held on Monday afternoon, December 4th, Sir James Crichton-Browne in the chair. Sir Arthur Keith was elected secretary in succession to the late Colonel E. H. Grove-Hills. Professors Urbain (Paris), Ehrenfest (Leyden), Knudsen (Copenhagen), Bjerknes (Christiania), and Dr. Irving Langmuir were elected honorary members. Miss Norah Forman, Mr. F. Hyde, Mr. J. B. Kramer, Mr. Alfonso Marconi, Mr. J. M. S. Marriner, Dr. R. B. Owens, and Miss T. Thomas were elected members.

KING'S COLLEGE ENGINEERING SOCIETY.—The annual dinner of King's College Engineering Society was held at the Connaught Rooms on Friday, November the 24th. Many distinguished engineers were present. The chairman, the Hon. C. A. Parsons, K.C.B., in proposing the toast of "The Engineering Society," said that young engineers must not forget the great debt they owe the early experimenters, such as Joule, without whose results so much of our present work would be impossible. Replying to the toast of "Our Guests," Dr. H. S. Hele-Shaw remarked that though several presidents of the other two great institutions were King's men, the office which he held had so far not been filled by an old student of King's College. The reply to this toast was ably seconded by Mr. W. Rutherford. A short musical programme brought a most successful dinner to a conclusion.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. Coast—	
Native	22/6
(1) Spanish	22/6
(1) N. African	22/6
N.E. Coast—	
Native	—
Foreign (c.i.f.)	21/6

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) Scotland—		
Hematite	5 7 6	—
No. 1 Foundry	5 0 0	—
No. 3 Foundry	4 15 0	—
N.E. Coast—		
Hematite Mixed Nos.	4 13 6	4 13 6
No. 1	4 14 6	4 14 6
Cleveland—		
No. 1	4 15 6	4 15 6
Silicious Iron	4 15 6	4 15 6
No. 3 G.M.B.	4 11 6	4 11 6
No. 4 Foundry	4 7 6	4 7 6
No. 4 Forge	4 2 6	4 2 6
Mottled	4 0 0 to 4 1 0	4 0 0 to 4 1 0
White	4 0 0 to 4 1 0	4 0 0 to 4 1 0
Midlands—		
(3) Staffs.—		
All-mine (Cold Blast)	13 0 0	—
North Staffs. Forge	3 12 6	—
,, ,, Foundry	4 4 0	—
(3) Northampton—		
Foundry No. 3	4 0 0	—
,, Forge	3 10 0	—
(3) Derbyshire—		
No. 3 Foundry	4 2 6	—
Forge	3 12 6	—
(3) Lincolnshire—		
Basic	4 0 0	—
Foundry	4 2 6	—
Forge	4 0 0	—
(4) N.W. Coast—		
N. Lancs. and Cum.		
Hematite Mixed Nos.	5 10 0	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
Scotland—		
Crown Bars	10 10 0	10 10 0
Best ,,	12 0 0	—
N.E. Coast—		
Crown Bars	10 10 0	—
Teas	10 0 0	—
Lancs.—		
Crown Bars	11 10 0	—
Second Quality Bars	10 5 0	—
Hoops	14 0 0	13 15 0
S. Yorks.—		
Crown Bars	12 0 0	—
Best ,,	12 10 0	—
Hoops	14 0 0	—
Midlands—		
Crown Bars	10 7 6 to 10 15 0	
Marked Bars (Staffs.)	13 10 0	—
Nut and Bolt Bars	9 12 6 to 9 15 0	
Gas Tube Strip	10 10 0 to 10 15 0	

STEEL.

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) Scotland—		
Boiler Plates	12 0 0	—
Ship Plates ¾in. and up	9 0 0	—
Sections	8 15 0	—
Steel Sheets ¼in. to ¾in.	10 10 0	—
Sheets (Gal. Cor. 24 B.G.)	—	17 10 0

STEEL (*continued*)

	Home. £ s. d.	Export. £ s. d.
N.E. Coast—		
Ship Plates	9 0 0 to 9 10 0	—
Angles	8 15 0 to 9 0 0	—
Boiler Plates	12 10 0	—
Joists	9 0 0	—
Heavy Rails	9 0 0	—
Fish-plates	13 0 0 to 14 0 0	
Channels	13 10 0	—
Hard Billets	8 15 0	—
Soft Billets	8 0 0	—
N.W. Coast—		
Barrow—		
Heavy Rails	8 10 0	—
Light ,,	9 10 0 to 10 0 0	
Billets	8 10 0	—
Manchester—		
Bars (Round)	9 0 0 to 9 10 0	
,, (others)	9 10 0 to 10 0 0	
Hoops (Best)	15 5 0	15 0 0
,, (Soft Steel)	12 5 0	12 0 0
Plates	9 0 0 to 10 0	
,, (Lancs. Boiler)	13 10 0	—
Sheffield—		
Siemens Acid Billets	9 10 0	—
Bessemer Billets	12 10 0	—
Hard Basic	8 15 0	—
Soft ,,	7 5 0	—
Hoops	11 10 0	—
Soft Wire Rods	10 0 0	—
Midlands—		
Small Rolled Bars	8 15 0	—
Billets and Sheet-bars	7 0 0	—
Gas Tube Strip	10 0 0 to 10 5 0	
Sheets (20 W.G.)	11 10 0 to 12 0 0	
Galv. Sheets (f.o.b. L'pool)	17 10 0	—
Angles	8 15 0	—
Joists	8 15 0 to 9 0 0	
Tees	9 10 0 to 10 0 0	
Bridge and Tank Plates	9 0 0 to 9 10 0	

NON-FERROUS METALS.

Swansea—	
Tin-plates, I.C., 20 by 14	19/6 to 19/9
Block Tin (cash)	176 0 0
,, (three months)	177 0 0
Copper (cash)	62 5 0
,, (three months)	63 2 6
Spanish Lead (cash)	25 17 6
,, (three months)	25 0 0
Spelter (cash)	38 7 6
,, (three months)	35 15 0
Manchester—	
Copper, Best Selected Ingots	66 0 0
,, Electrolytic	70 0 0
,, Strong Sheets	96 0 0
,, Loco Tubes	0 1 1½
Brass Loco Tubes	0 0 11½
,, Condenser	0 1 2½
Lead, English	27 5 0
,, Foreign	26 0 0

FERRO ALLOYS.

(All prices now nominal.)

	Per Ton.	Per Unit
Tungsten Metal Powder	1/11 per lb.	
Ferro Tungsten	1/5 per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£22	10/6
,, 6 p.c. to 8 p.c. ,,	£21 0 0	7/-
,, 8 p.c. to 10 p.c. ,,	£20 0 0	7/-
,, Specially Refined		
,, Max. 2 p.c. carbon	£54 0 0	20/-
,, ,, 1 p.c. ,,	£64 0 0	22/6
,, ,, 0·75 p.c. carbon	£72 0 0	25/-
,, carbon free	1/7 per lb.	
Metallic Chromium	4/9 per lb.	
Ferro Manganese (per ton)	£15 for home.	
,, Silicon, 45 p.c. to 50 p.c.	£11 2 6 scale 5/- per unit	
,, ,, 75 p.c.	19 10 0 scale 6/- per unit	
,, Vanadium	17/- per lb.	
,, Molybdenum	9/6 per lb.	
,, Titanium (carbon free)	1/2 per lb.	
Nickel (per ton)	£160	
Cobalt	11/- per lb.	
Aluminium (per ton)	£82 to £100 (British Official.)	

FUELS.

SCOTLAND.

	Export.
Lanarkshire—	
(f.o.b. Glasgow)—Steam	24/- to 24/6
,, ,, Ell	25/- to 25/3
,, ,, Splint	26/- to 28/-
,, ,, Trebles	24/-
,, ,, Doubles	22/-
,, ,, Singles	17/9
Ayrshire—	
(f.o.b. Ports)—Steam	24/-
,, ,, Splint	26/-
,, ,, Trebles	24/-
Fifeshire—	
(f.o.b. Methil or Burntisland)—Steam	22/6 to 25/6
Screened Navigation	28/-
Trebles	25/-
Doubles	22/6
Singles	18/6
Lothians—	
(f.o.b. Leith)—Best Steam	24/6
Secondary Steam	23/9
Trebles	24/9
Doubles	22/6
Singles	19/-

ENGLAND.

(8) N.W. Coast—	
Steams	49/6
Household	46/8 to 57/6
Coke	34/8
Northumberland—	
Best Steams	25/6 to 26/-
Second Steams	23/- to 24/-
Steam Smalls	12/6 to 14/6
Unscreened	20/6
Household	25/- to 28/-
Durham—	
Best Gas	24/- to 25/-
Second ,,	22/- to 23/-
Household	25/- to 28/-
Foundry Coke	37/- to 40/-

Sheffield—	Inland.
Best Hand-picked Branch	32/6 to 34/6 —
Barnsley Best Silkstone	28/- to 30/- —
Derbyshire Best Brights	24/- to 26/- —
,, ,, House	21/6 to 22/6 —
,, ,, Large Nuts	19/6 to 22/6 —
,, ,, Small ,,	15/- to 16/6 —
Yorkshire Hards	20/- to 21/- —
Derbyshire ,,	19/- to 20/6 —
Rough Slacks	9/- to 11/- —
Nutty ,,	7/9 to 9/9 —
Smalls	3/- to 5/- —
Blast Furnace Coke (Inland and Export)	21/- to 30/-

(9) SOUTH WALES.

Cardiff—	
Steam Coals:	
Best Smokeless Large	28 6 to 29/6
Second ,, ,,	27/6 to 28/6
Best Dry Large	28/6 to 29/6
Ordinary Dry Large	27/6 to 28/6
Best Black Vein Large	27/- to 27/6
Western Valley ,,	27/- to 27/6
Best Eastern Valley Large	26/6 to 27/6
Ordinary ,, ,,	23/- to 25/-
Best Steam Smalls	17/- to 18/-
Ordinary ,,	14/- to 16/-
Washed Nuts	27/6 to 37/6
No. 3 Rhondda Large	28/- to 30/-
,, ,, Smalls	19/- to 21/-
No. 2 ,, Large	23/6 to 24/6
,, ,, Through	19/6 to 22/6
,, ,, Smalls	14/- to 15/-
Coke (export)	37/6 to 42/6
Patent Fuel	28/- to 30/-
Pitwood (ex ship)	33/- to 33/6
Swansea—	
Anthracite Coals:	
Best Big Vein Large	40/- to 42/6
Seconds	30/- to 32/6
Red Vein	30/- to 32/6
Machine-made Cobbles	50/- to 52/6
Nuts	65/- to 67/6
Beans	42/6 to 45/-
Peas	22/- to 23/-
Breaker Duff	10/6 to 11/-
Rubbly Culm	14/- to 15/-
Steam Coals:	
Large	25/- to 26/-
Seconds	23/- to 25/-
Smalls	10/- to 12/-
Cargo Through	17/- to 20/-

(1) Delivered. (2) Net Makers' works. (3) At furnaces. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire and Ayrshire.

(6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/- extra delivered England (7) Export Prices—F.O.B. Glasgow.

(8) Except where otherwise indicated coals are per ton at pit for inland and f.o.b. for export and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b.

French Engineering Notes.

(From our Correspondent in Paris.)

Increasing Costs.

THE effect of the depreciation of money values is necessarily to increase costs. So much is said of the cheapness of manufacture in countries with a huge fiduciary circulation that it is often overlooked that the production costs only remain low during the process of levelling up, that is to say, while the prices of commodities are slowly rising to adjust themselves to the rapid currency depreciation. A fall in the value of the franc has therefore little immediate effect upon home values, and the cost is low compared with the prices in countries with sounder currencies; but the home values steadily advance, and this advance is observable first in raw material, of which a large part has to be purchased abroad, and the final result is a scaling up of prices all round. In England, on the other hand, the efforts to bring down prices from a maximum have the effect of a slow and consistent cheapening of products. If this state of things should continue the time will come when countries with a sane currency and a well-organised industry will be producing more cheaply than countries in which monetary values are becoming more and more forced. Except that pig iron prices have appreciated on account of the scarcity of coke, there is no reason why the prices of raw materials here should have advanced other than that the exchange rate has raised the values of imported products. The French are hoping to overcome the difficulty by dispensing with foreign material and products altogether, and the active colonial programme now being carried out aims at rendering the country independent of foreign supplies; but as all these efforts at making France self-supporting can only give results after many years and with an enormous expenditure of capital, there is little reason for believing that the French will be able to do without foreign supplies. So long as they have to buy from abroad under present conditions the costs of production will continue to increase.

Pig Iron.

While the values of raw and manufactured materials are hardening, it is becoming more and more difficult to procure sufficient supplies of pig iron. The production has been seriously limited by the scarcity of coke, and also by the considerable diminution in the quantities of iron and steel scrap available, due to the huge consignments being sent abroad, principally to Germany. In a little more than a year the consignments of scrap abroad have increased from 18,000 tons to 75,000 tons a month. The Government is now being pressed to take measures to prevent the export of scrap which is so badly needed by furnace owners. It is believed that the coke stringency will be alleviated very shortly.

Moving Platforms.

The thirty-eight schemes which have been submitted for an underground moving platform, in response to the competition opened by the Paris Municipal Council, are to be examined by three commissions in the hope that a decision will be come to by the end of the month. The problem is not so easy of solution as had been anticipated, for the moving platform must be installed under at least as favourable conditions as the Metropolitan Railway, of which the only drawbacks are the loss of time in getting to and from the trains and in the limited capacity, which is about 12,000 passengers an hour, with a maximum of 18,000. The moving platform must also be capable of operating on steep gradients, such as the Rue de Belleville, which is at present served by a cable tramway, and if the new system of transport is definitely adopted it will probably be laid down first on the most difficult route from the north to south of Paris. The difficulties are of a purely technical character, for there can be no doubt about the superiority of the moving platform from the point of view of carrying capacity, while the speed is above that of motor omnibuses in the busiest thoroughfares. The moving platform at the Paris Exhibition in 1900 carried 50,000 persons an hour at a speed of 12 kiloms.

Automatic Brakes.

About three months ago the Technical Commission, which was appointed to carry out tests of the three continuous braking systems presented for adoption on goods trains, concluded that the best all-round results were obtained with the Westinghouse brake, and suggested that the French Government should recommend its application, in combination possibly with other systems, by the countries signing the Berne Convention. This report was submitted to experts appointed by the Railway Consulting Committee which has issued a further report in which it objects to the Technical Commission's conclusions. It states that the only practical way of deciding upon the relative merits of these systems is to fit a number of goods trains in actual service with the Westinghouse, Clayton-Hardy and Lipkowski continuous brakes and run them as long as possible.

Explosive Anthracite.

The strange explosions which began about two weeks in slow combustion stoves using British anthracite, and which have since extended with more serious consequences to other kinds of fuel, have been proved to be due largely, if not wholly, to the criminal introduction of explosive agents, apparently after the arrival of the fuel in Paris. This partly disposes of the fear which was gaining ground that British anthracite was becoming a dangerous fuel to handle. At the same time publicity has been given to a theory that the minor explosions that started with anthracite may have been due to natural causes. It is explained that certain anthracites, notably those found in some parts of France, contain gas under very high pressures which, on being subjected to heat in a stove, would explode. British anthracite has always been free from any such risk. Whether there has been a mixture of such anthracites, or whether all the explosions are due to the criminal introduction of dangerous engines, is a question that has not yet been cleared up.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent Office Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

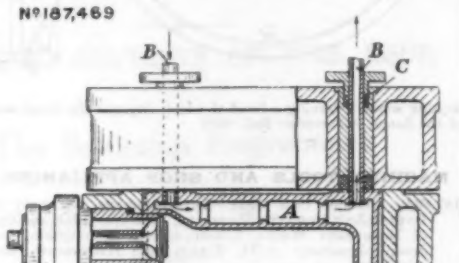
The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES.

187,469. November 3rd, 1921.—COOLING CYLINDER HEADS, *T. W. Rogers, Brewer and Son*, 33, *Chancery-lane, London.*

In this cylinder head a loose water jacket A is provided. It surrounds the valve pockets as shown, and incidentally protects the cylinder cover from the direct action of the heat of explosion.

Nº187,469



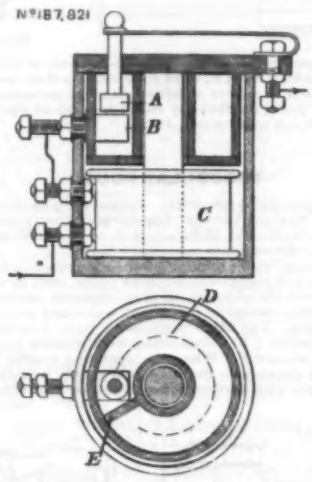
The jacket is free to expand in consequence of changes of temperature and is supplied with water through flexible pipes B B passing through stuffing-boxes C. The valve shown in the drawing is described as a scavenging valve.—*October 26th*, 1922.

SWITCHGEAR.

187,821. October 5th, 1921.—IMPROVEMENTS RELATING TO MAGNETIC BLOW-OUT DEVICES FOR USE WITH ELECTRIC CIRCUIT CONTROLLING APPARATUS, George Ellison and James Anderson, both of Wallhead-lane Works, Perry Barr, Birmingham.

A strong electro-magnet is arranged in conjunction with the stationary contact B and movable contact A. The magnet may be in the form of a hollow cylindrical iron body C having an axial core and a series or other winding situated at one end of the body and the core, so that between the other ends of the body and core a strong radial magnetic field is produced. When the contacts

Nº187,821



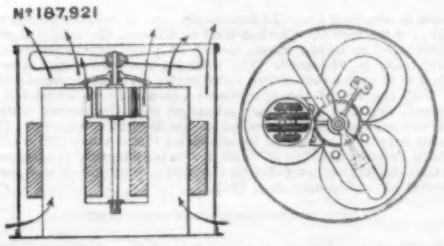
are separated and an arc is formed, the arc is extended in a circular path as indicated by the dotted line D. To prevent the arc from describing a complete circle a non-conducting obstruction E may be employed at any suitable position in the arc path. By this invention it is said to be possible to localise the arc much more effectively than is possible with ordinary blow-out devices, and it is found that the arc can be extinguished with a smaller separation of the contacts than usual.—*November 2nd*, 1922.

TRANSFORMERS AND CONVERTERS.

187,921. May 18th, 1922.—IMPROVEMENTS IN OR RELATING TO THE COOLING OF ELECTRIC TRANSFORMERS AND SIMILAR APPARATUS, *William Henry Sims, of* 14 *and* 15, *Conduit-street, London.*

According to this invention static transformers or induction

Nº187,921



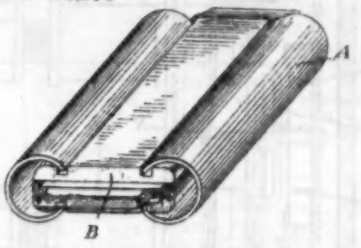
regulators are cooled by a fan driven by the main flux or by the magnetic leakage. In the case illustrated the motor of the fan is arranged in a cavity at the ends of the three magnetic cores on which are wound the coils of the polyphase transformer. The shaft of the motor carries a fan, the wings of which being at the top of the apparatus. A casing is provided to guide the currents of air passing through the ventilation holes of the cores in the required direction. To increase the power of the fan the section of the magnetic circuit in the neighbourhood of the motor may be reduced, and for this purpose radial slots may be made in the part of the magnetic core adjacent to the motor.—*November 2nd*, 1922.

ELECTRICAL APPLIANCES.

175,236. August 3rd, 1921.—IMPROVEMENTS IN ELECTRIC CONDENSERS AND CLAMP THEREOF, William Dubilier, of 217, Centre-street, New York.

The electric condenser described in this specification consists of the usual dielectric sheets and conducting sheets, and the "stack" formed of these sheets is preferably impregnated and then subjected to a high pressure. To obtain the desired efficiency it is desirable that the elements of the condenser be

Nº175,236



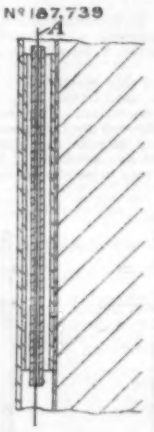
kept under sufficient pressure whilst they are in use to ensure the intimate contact between the dielectric and conducting sheets. According to this invention the compression is applied to the stack by means of arched members A, which are forced over the bearing members B in the manner shown, the arched members A being made of springy material, such as steel.—*November 2nd*, 1922.

LIGHTING AND HEATING.

187,739. August 6th, 1921.—IMPROVEMENTS IN ELECTRIC HEATING, Herbert Harrison, of 9, Northstead-road, Palace-road, Tulse Hill, S.W.

The system of electric heating described in this specification involves the use of an electric conductor run at a comparatively low temperature. This conductor, which is shown at A, is first covered with tubes or bends composed of silica, porcelain,

Nº187,739



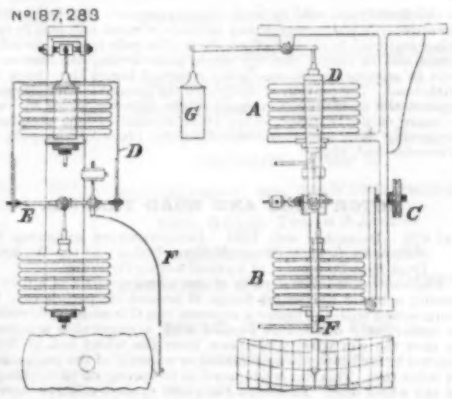
asbestos, or other suitable material, and is then enclosed in a metallic enamelled tube having a considerably larger diameter than the wire and covering. This metallic tubing is embedded in the material forming the surface of the walls or other structural part of the room or building.—*November 2nd*, 1922.

MEASURING AND TESTING INSTRUMENTS.

187,283. June 20th, 1921.—ANEROID PRESSURE GAUGES, J. F. Simmance, 1, Westminster Palace-gardens, London, S.W. 1.

This gauge is intended for recording the difference of pressure in two containers by means of the two corrugated aneroid chambers A and B. Both chambers are supported from the main frame at their lower extremities, the bracket for B having a screw

Nº187,283

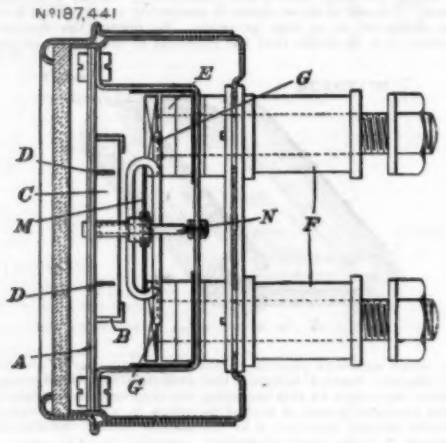


adjustment C for height. To the top of A there is attached a stirrup D, in which there is pivoted the spindle E that carries the pointer F. Connected with the top of the stirrup there is the counterweight G. The lower chamber is connected with a short crank arm on the spindle E. The arrangement is such that

similar variations in the pressure in the two chambers will not swing the pointer, but differences in the pressure will give it an angular movement. The counterweight G is said to minimise the effect in differences in the elasticity of the chambers.—*October 20th*, 1922.

187,441. October 11th, 1921.—IMPROVEMENTS RELATING TO ELECTRICITY MEASURING INSTRUMENTS, Harry Lucas, Elisha John Bryant Danks, and Oswald Augustine Miller, all of Great King-street, Birmingham.

The object of this invention is to simplify the construction of electrical instruments, such as ammeters, used on motor cars. Behind the main plate A, which has a scale on the outer side, are two tongue pieces B which clip the ends of a short bar magnet C, and to prevent side movement of the magnet two other tongue pieces D are provided. A metal bridge piece E carries a pair of terminal posts F, and to the inner ends of these posts the ends G

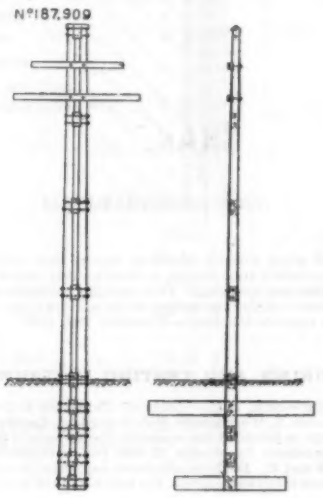


of a rigid coil of stiff wire are connected. A transverse hole in each of the posts, through which one end of the coil of wire is inserted, enable the coil to be adjusted. The usual iron armature M is mounted on an arbor N carried in bearings on the main plate and bridge piece and the arbor has an index finger attached to it. The zero position is adjusted by moving the index finger relative to the arbor, and the calibration of the instrument is adjusted by moving the coil relatively to the magnet.—*October 20th*, 1922.

TRANSMISSION OF POWER.

187,909. March 1st, 1922.—DOUBLE-POLE FOR SUPPORTING TELEGRAPH, TELEPHONE AND ELECTRIC POWER WIRES, Joseph Ernest Rutter, 8, Faraday-street, Holderness-road, Hull.

The pole described in this specification is composed of two single poles of the type used for the support of telegraph, telephone, electric power wires, &c. They are connected to each other by bolts passing through distance pieces, which keep them a small distance apart, and the poles may either be parallel or they may taper. The poles are notched for the reception of the distance pieces, which vary in number and position with the size

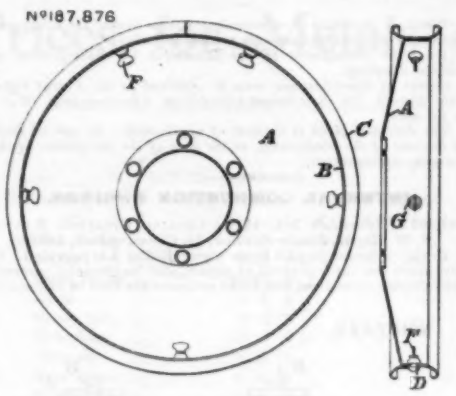


of the double pole and the load it has to support. The purpose of these distance pieces, which may be made of wood, cast iron or any other material, is to strengthen the double pole against shearing stress and to ensure the two single poles acting together as a unit in offering resistance to the external forces they have to withstand. The portion of the pole in the ground is strengthened against the overturning moment of the exterior forces by two or more of the distance pieces being formed of long members projecting in a direction normal to the plane of the pole.—*November 2nd*, 1922.

MOTOR CARS AND ROAD TRAFFIC.

187,876. December 3rd, 1921.—IMPROVEMENTS RELATING TO MOTOR VEHICLE WHEELS, William Dukes and the Warland Dual Rim Company, of Lythall's-lane, Coventry.

The central or main portion of the wheel consists of a disc A having a broad horizontal flange B around its periphery. In conjunction with the flange a separate rim C is employed, which is transversely divided or formed with a removable segment, so that the rim when withdrawn from the wheel can be contracted to facilitate the attachment or removal of the pneumatic or other tire. This rim is adapted to be sprung on to the flange of the wheel disc. To secure the parts against relative lateral displacement a number of short radial studs D are arranged to project inwardly through holes in the rim, these being pressed through the rim either by the pressure of the tire or by springs placed between the rim and the tire. Corresponding holes are provided in the flange which carries the rim, and in the act of placing the rim in position the studs are caused to engage the holes in the flange. To prevent accidental disconnection of the studs when the rim is in position, a screwed hole is formed axially in each of the studs for the attachment thereto of a

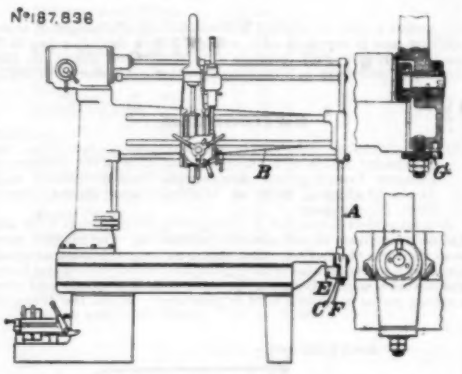


locking screw F having a head G which engages the inner side of the flange.—*November 2nd*, 1922.

MACHINE TOOLS AND SHOP APPLIANCES.

187,836. October 19th, 1921.—IMPROVEMENTS RELATING TO RADIAL ARM DRILLING MACHINES, James Archdale and Co., of Manchester Works, Ledsam-street, Birmingham, and Joseph Jewsbury, of 34, Witton-road, Handsworth, Birmingham.

The lower end of a stay A attached to the outer end of the radial arm B is provided with a roller C or rollers, preferably carried on ball bearings, which rests upon the upper surface of a flat circular track or guide E on the machine bed. An extension of the stay or a portion of it which is below the roller has

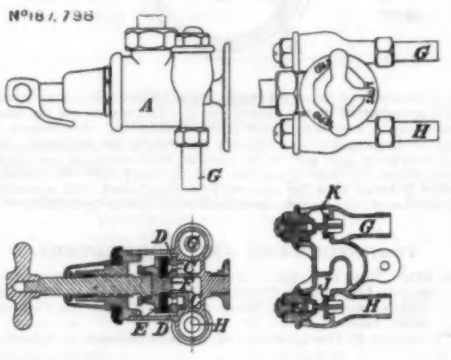


secured to its underside a slide which co-operates with the underside of the guide or track E. The slide consists of an overhanging plate F adapted to receive a slight rocking movement relatively to a fulcrum peg G on the stay and is secured to the stay by a stud or screw.—*November 2nd*, 1922.

MISCELLANEOUS.

187,796. September 12th, 1921.—IMPROVEMENTS IN OR RELATING TO MIXING VALVES, Shanks and Co., Limited, and Thomas McDonald McInnes, both of Tubal Works, Barrhead, Renfrewshire.

This invention relates to mixing valves for effecting the control and admixture of supplies of different fluids, such as steam and cold water, and the object is to give improved means for controlling the temperature of the mixing water and preventing the risk of scalding. The valve comprises a body A with a double concentric seating C D co-operating with a valve presenting a face E and a plunger F. When the operating handle is turned, cold water is drawn first from the cold supply pipe G over the seating D and, with further turns of the handle, hot water or



steam is admitted from the hot supply pipe H past the plunger F and over the face C. The hot fluid mixes with the cold and produces tepid or mixed water, but at no point can steam or hot water only be obtained. The inlet on the cold water side is fitted at K with a non-return valve with provision for regulation, so that the lift of the non-return valve may be restricted if desired, and less cold water admitted into the mixing valve, thereby raising the temperature of the final mixed water. The steam supply is controlled by the usual steam valve and a non-return valve is fitted at J. The device is preferably constructed so that the non-return valve on the cold side cannot at any point be shut off.—*November 2nd*, 1922.

CONTRACTS.—William Beardmore and Co., Limited, whose locomotive works are at Dalmuir, near Glasgow, have received a contract for five heavy and powerful locomotives of the "Mallet" articulated type, metre gauge, for the Burmese Railways.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

THE JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, S.W. 1. Lecturette, "The Michell Thrust Bearing" (slides), by Mr. J. Ward. 7.30 p.m.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Storey's-gate, S.W. 1. Informal meeting. Lecture, "The Manufacture of Solid-drawn Steel Tubes and their Jointing" (slides), by Captain J. A. Richards. 7 p.m.

THE INSTITUTE OF METALS: SHEFFIELD LOCAL SECTION.—Mappin Hall, St. George's-square, Sheffield. Paper, "Cobalt," by Mr. W. R. Barclay. 7.30 p.m.

PHYSICAL SOCIETY OF LONDON.—Imperial College of Science, South Kensington, S.W. 7. Ordinary general meeting. 5 p.m.

THE INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—The Engineers' Club, Coventry-street, W. 1. Lecture: "Centrifugal Pumps as Applied to Heating Installations," by Mr. A. H. Barker. 7 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Literary and Philosophical Society, Newcastle-upon-Tyne. "Note on the Presentation of Model Experiment Data," by Mr. E. V. Telfer. 7.30 p.m.

SATURDAY, DECEMBER 9TH.

KEIGHLEY ASSOCIATION OF ENGINEERS.—Cycling Club, Cavendish-street, Keighley. Lecture: "Ceylon and South India," by Mr. H. Gordon Cran. 6.30 p.m.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Newcastle-upon-Tyne. General meeting. 2 p.m.

MONDAY, DECEMBER 11TH.

BRADFORD ENGINEERING SOCIETY.—Technical College, Bradford. Lecture: "Spinning Tops and Gyroscopic Motion," by Mr. L. C. Perkin. 7.30 p.m.

TUESDAY, DECEMBER 12TH.

INSTITUTE OF INDUSTRIAL ADMINISTRATION.—London School of Economics, Houghton-street, Aldwych, W.C. 2. Lecture, "Standardisation of Repairs in Relation to Industrial Economy," by Mr. R. Twelvetrees. 8 p.m.

THE JUNIOR INSTITUTION OF ENGINEERS.—Royal United Service Institution, Whitehall, S.W. 1. Presidential address: "The Utility of Theory to the Practical Man," by Captain H. Riall Sankey. 7.30 p.m.

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH CENTRE.—207, Bath-street, Glasgow. Paper: "The Possibilities of Transmission by Underground Cables at 100,000/150,000 Volts," by Mr. A. M. Taylor. 7.30 p.m.

THE JUNIOR INSTITUTION OF ENGINEERS: NORTH-EASTERN SECTION.—Armstrong College, Newcastle-on-Tyne. Paper: "The Heavy Oil Engine," by Mr. J. Calderwood. 7.15 p.m.

THE ELECTRO-HARMONIC SOCIETY.—Caxton Hall, Westminster, S.W. 1. Smoking concert. 8 p.m.

MANCHESTER GEOLOGICAL AND MINING SOCIETY.—Queen's Chambers, 5, John Dalton-street, Manchester. Paper: "Fuel Economy in Colliery Steam Plant," by Mr. A. Grounds. 3 p.m.

WEDNESDAY, DECEMBER 13TH.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—The Institution of Mechanical Engineers, Storey's-gate, S.W. 1. Paper, "Improvements in Efficiency of Roadless Vehicles," by Lieut.-Colonel P. H. Johnson. 7.45 p.m.

THURSDAY, DECEMBER 14TH.

NORTHAMPTON ENGINEERING COLLEGE ENGINEERING SOCIETY.—St. John-street, Clerkenwell, E.C. 1. Paper: "Steam Turbines," by Mr. L. G. Semple. 5.30 p.m.

THE OPTICAL SOCIETY.—Imperial College of Science and Technology, South Kensington, S.W. 7. Papers: "A Large Aperture Lens not Corrected for Colour," and "The Optical Cosine Law," by Mr. T. Smith. 7.30 p.m.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Savoy-place, Victoria Embankment, W.C. 2. "Electric Arc Welding Apparatus and Equipment," by Mr. J. Caldwell. 6 p.m.

INSTITUTION OF BRITISH FOUNDRYMEN.—Institute of Marine Engineers, 85–88, The Minories, E. 1. Joint meeting with the Institute of Metals (London Section). "Brass and Bronze Foundry Practice," by Mr. P. Longmuir. 7.30 p.m.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—28, Victoria-street, S.W. 1. London graduates' meeting. Paper: "The Design of Connecting-rods for High-speed Petrol Engines," by Mr. M. Platt. 8 p.m.

THE INSTITUTION OF STRUCTURAL ENGINEERS.—Denison House, 296, Vauxhall Bridge-road, S.W. 1. Paper: "The Strength of Rectangular Slabs," by Mr. A. Ingersley. 7.30 p.m.

FRIDAY, DECEMBER 15TH.

THE JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, S.W. 1. Lecturette: "Notes on Printing Machinery," by Mr. W. T. Marchment (slides). 7.30 p.m.

THE INSTITUTION OF PRODUCTION ENGINEERS.—The Engineers' Club, Coventry-street, W. 1. Paper: "The Production Engineer," by Mr. H. E. Honor. 7.30 p.m.

THE INSTITUTION OF AERONAUTICAL ENGINEERS.—The Engineers' Club, Coventry-street, W. 1. Paper: "Experimental Data without Wind Channel," by Mr. O. T. Gnospelius. 6.30 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Literary and Philosophical Society, Newcastle-on-Tyne. "Wireless Broadcasting and its Possibilities," by Mr. A. P. M. Fleming. 7.30 p.m.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Storey's Gate, S.W. Paper: "Reclamation Plant and its Operation," by Gascoigne Lumley. 6 p.m.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

THE Yorkshire Copper Works, Limited, Leeds, which have been represented in London by F. S. Dudgeon and Havart, Limited, have now opened their own offices at 53, New Broad-street, London, E.C. 2 (Telephone 1662 London Wall; telegrams, "Yorkopper, Ave., London.") The office is in charge of Mr. Kenneth P. Symes.